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THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

SPRING MEETING, CINCINNATI, MAY 21 TO 24

· MARCH · 1917 ·

Volume 39 Number 3

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

MARCH, 1917

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PUBLISHED MONTHLY BY

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 West Thirty-ninth Street, New York

Price $3 Copy, $3.00 a Year; to Members and Affiliates, 25 Cents a Copy, $2.00 a Year. Postage to Canada, 50 Cents Additional; to Foreign Countries, $1.00 Additional.

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Entered at second-class matter January 6, 1879, at the Postoffice, New York, N. Y., under the act of March 3, 1879.

HEAT TREATMENT OF WROUGHT-IRON CHAIN CABLE

An Original Investigation of the Causes of the Comparative Weakness of Power-Forged Wrought-Iron Chain, with Results of Experiments Leading to a Method of Heat Treatment for Their Removal

By W. W. WEBSTER[1] and E. L. PATCH[2]

With Foreword by F. G. Coburn, Naval Constructor, U. S. N.

THE following paper on the thermal treatment of wrought iron is a restatement of the graduation thesis on that subject prepared by W. W. Webster and E. L. Patch, Assistant Naval Constructors, U. S. Navy, at The Massachusetts Institute of Technology.

The subject was suggested by the writer, as a result of experience at the U. S. Navy Yard, Boston, Mass., in the manufacture of chain cables for naval vessels. Prior to July 1, 1914, all chain cables for the Navy were manufactured at that yard, by hand, after the fashion of the old English chain-makers, still followed in other chain shops in this country. Experiments had been under way for several years, looking toward a steam-hammer process, and such a process had, at that time, been developed; satisfactory to the extent that it effectively and cheaply welded the chain, but unsatisfactory in that the chain, apparently perfect, would not meet the breaking-strength requirements.

It became suddenly necessary, in July, 1914, to make the process work in order to supplant hand manufacture. The writer, just at that time, came into direct charge of the work. The process seemed to be good, but it was mystifying, indeed, to see apparently perfect chain snap off under test like cast iron. It seemed as if an *addition* to the process was needed, rather than a change; and heat treatment suggested itself. There was no literature available on the heat treatment of either iron or low-carbon steel. In fact, this thesis appears to

FIG. 1 HEAVY PEARLITE STRUCTURE—FROM HEAVILY-SHADED AREAS IN FIG. 5

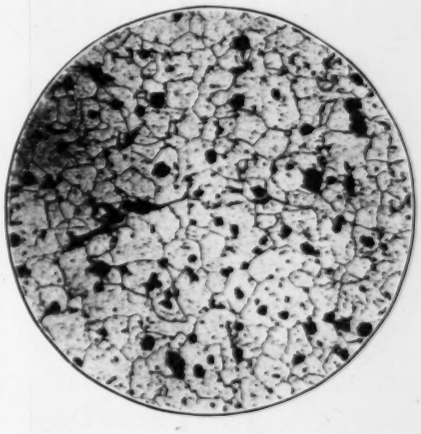

FIG. 2 PURE IRON STRUCTURE—FROM LIGHTEST AREAS IN FIG. 5

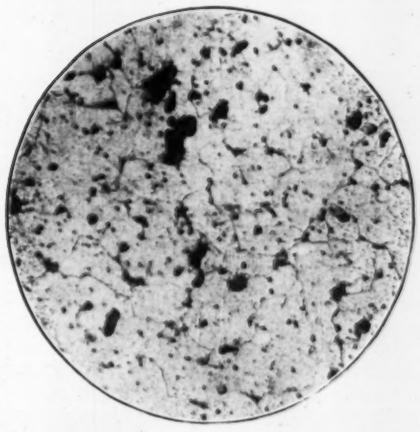

FIG. 3 FERRITE STRUCTURE WITH TRACES OF PEARLITE—FROM LIGHTLY-SHADED AREAS IN FIG. 5

FIG. 4 ADJACENT AREAS OF HIGH AND LOW CARBON (50 DIAMETERS)

FIGS. 1 TO 4 CHARACTERISTIC MICROPHOTOGRAPHS FROM BURDEN WROUGHT IRON

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[2] Portsmouth Navy Yard.

Presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 1916. The paper is here printed in abstract form. Pamphlet copies without discussion may be obtained; price 15 cents to members, 30 cents to non-members.

be the first work of its kind. A number of engineers familiar with the art of heat treatment were consulted by the writer, but none of them knew of any work having been done which would be of assistance.

It was peculiar that *hand*-welded chain was successful under test; yet we knew that it was not so thoroughly welded as the *hammer*-welded chain. The latter was very thoroughly hammered, too, and kneaded, so that it should be stiff and strong. In this very stiffness the trouble finally was found.

The distribution of stresses in a studded link under tension is such that there are maxima of bending moment at the ends of the axes of the link and maxima of shear at the quarters. It is well known that iron is weaker in shear than in tension. It was observed that the hammer-welded links always failed in the quarters; that while the hand-welded links stretched freely, the power-welded links would not stretch much prior to breaking.

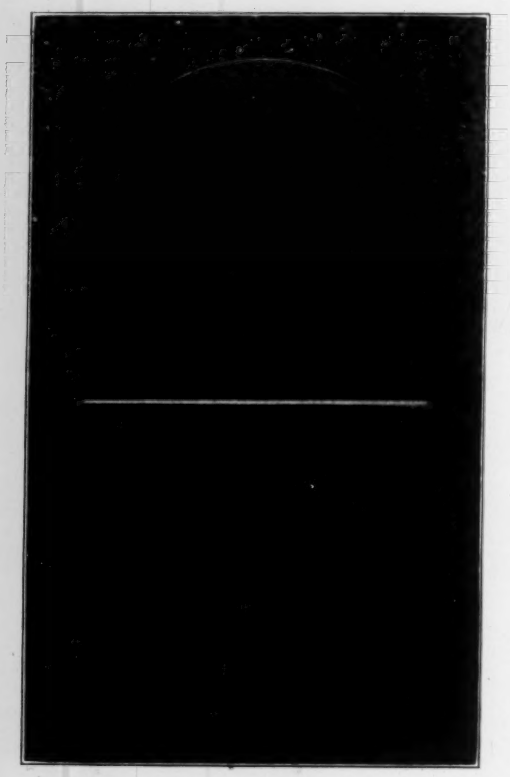


FIG. 5 SECTION OF BURDEN IRON ETCHED 30 MINUTES

The following hypothesis was then formulated by the writer, to explain the above phenomena: That the hammer-welded link was so stiff that the shearing stress could build up in the quarters to such a degree that the link would fail by shearing, whereas the hand-welded link was soft and ductile enough to deform under the shearing stress, failure occurring later due to a combination of shear and tension when a higher applied tensile load was reached.

There was no pyrometric equipment available; so in the first experiments, which were necessarily crude, the writer gaged temperatures by eye. Test doublets were heated to a temperature believed to be above the upper critical point, cooled in air, and pulled, giving satisfactory results as regards stretch, character of fracture, and ultimate tensile strength. Heat treatment was plainly the answer to the problem.

The writer therefore proceeded to equip a laboratory and to equip the shop for temperature measurement. After some experimenting, a method of heat treatment was evolved which gave fairly good results. But these results were not always consistent, and while the plant was put on a manufacturing basis, still there were very puzzling questions arising. It was considered very desirable, indeed, to find out really why heat treatment was required for power-forged chain and not for hand-welded chain, what the very best heat treatment should be, how much heat treatment wrought iron would respond to, and, in general, to develop working standards for shop practice.

Messrs. Webster and Patch took up the task as their graduation thesis, being assisted in the work later by J. J. Crowe, Physical Metallurgist, who came to the work from the Bureau of Standards by courtesy of the Director, Dr. S. W. Stratton, and of Dr. G. K. Burgess.

F. G. COBURN.

MANUFACTURE OF POWER-FORGED CHAIN

The various operations involved in the process of power-forging chain are briefly as follows:

Shearing. The bar of round stock is rolled from the storage skids on to rollers which guide it through the shears and against the stop which gages the length of the "bolts." After cutting off, the bolts are packed in special baskets for transfer by crane to the scarfing furnace.

Scarfing. One end of the bolt is heated in a special oil furnace for a distance of about a foot and the end is then bent and upset by a single operation in the upsetting machine. During the same heat the bolt is scarfed under a 2500-lb. steam drop hammer, using special steel dies. The "flash" or web is then removed by a trimming press. The operation is repeated for the other end and the bars are packed in baskets for transport to the bending-machine furnace.

Bending. The scarfed link is heated throughout to about 1100 deg. cent. in a special oil furnace, from which it is swung by a special jib crane to the hydraulic bending press. Here it is bent by wiping it around a mandrel having the shape of the inside of the chain link. This operation leaves the links practically closed and it is necessary to pry apart the scarfs with a crowbar in order to thread the links in the chain.

Welding. The link is first preheated, threaded into the end of the growing chain, and the scarfs closed under a heavy hammer. It is then brought to a welding heat of about 1350 deg. cent. in a special oil-burning chain forge and welded on special "dolly dies" under a light hammer (250-350-lb.). To give the link the proper shape it is brought to welding heat a second time and finished in the dies of the heavy hammer (1800-3000-lb.).

Trimming. The last welding process leaves a "drop-forge flash" inside and outside on the welded end of the link, which is trimmed off by hand.

Studding. The drop-forged chain stud, which is inserted to preserve the shape of the link, increase the strength, and prevent kinking of the chain, is held in place with the link on its side under the steam hammer and pinched in place by a light blow of the hammer.

Heat Treatment. This is accomplished by loading the chain on to a steel flat car, which is run into a long annealing furnace fired by oil burners. The temperature is brought evenly to about 950 deg. cent., well above the upper critical point, as determined by the indications of nine base-metal thermocouples distributed about the furnace, one couple being placed in a bolt of iron under the pile of chain on the car. After the

desired temperature has been maintained for 10 minutes the car is hauled out of the furnace and the chain allowed to cool in the air before proofing.

Proofing. Each shot of chain is given a "proof test" with the hydraulic testing machine up to values given in the chain tables. After proofing, each link of the shot is examined for defects, and if unsatisfactory links are found they are cut out and replaced by the repair crews. In addition to the proof test, a breaking test is made on a "doublet" taken at random during the making of each shot. If this does not equal the tabulated standard others are tried on each side, and if they fail the whole shot is condemned. The proofing load is approximately 60 per cent of the breaking load. The tables of stresses are standard with the Navy Department, being based on both foreign and domestic practice.

Painting. Shots which have been proofed and found satisfactory are coated by hauling through a hot bath of asphalt paint, and are then stowed ready for shipment.

PROPERTIES OF STOCK MATERIAL

At present the iron used for the most important sizes of chain is made by the Burden Iron Company, of Troy, N. Y. The Government requires grade "A" American refined iron, puddled from all-ore pig iron, free from admixture of steel or scrap; phosphorus not to exceed 0.10 per cent and sulphur not to exceed 0.015 per cent.

Chemical analysis of Burden iron, made by the chemical laboratory of the Boston Navy Yard from borings taken from several stock bars, gave the following average results:

Carbon	0.10 per cent
Silicon	0.10 per cent
Phosphorus	0.085 per cent
Sulphur	0.008 per cent

Twelve tensile specimens cut from a 3¼-in. bar gave the results summarized below, which are compared with the Government specification requirements:

	Test results.	Specification.
Yield point, lb. per sq. in.	26,100	24,000
Tensile strength, lb. per sq. in.	49,000	48,000
Elongation, per cent.	35.5	26
Contraction of area, per cent.	50	40

Charpy impact tests of eight specimens averaged as follows, and indicate the difference of resistance to shock due to the direction of the slag fibers:

Longitudinal, 150 ft-lb. per sq. in.
Transverse, 39 ft-lb. per sq. in.

The appearance of the transverse and longitudinal sections of a stock bar, when polished and etched, is shown in Fig. 1, which brings out clearly the outlines of the different bars and slabs, known as grade "B" bars, which were piled together to make up the finished grade "A" bar. Also each grade "B" bar is seen to be made up of well-defined areas of different shades or depths of color, representing the muck bars from which it was rolled.

Under the microscope the heavily shaded areas have a pearlite and ferrite structure, with numerous slag spots (Fig. 5), showing them to be wrought iron with about 0.20 per cent carbon. The more lightly shaded areas indicate less pearlite (Fig. 2), typical of about 0.05 per cent carbon, and the unshaded areas a pure wrought-iron structure (Fig. 3). Metallographic examination was made of specimens cut from three stock bars all of which displayed the same characteristics of segregated carbon; the line between adjacent areas of high carbon content and of low carbon is frequently very sharp, as in Fig. 4.

HEAT TREATMENT OF BURDEN CHAIN IRON

The thermal analysis of the iron, or the determination of its "critical" points, is quite necessary for an intelligent study of its heat treatment. In Fig. 6 are typical heating and cooling curves for Burden iron, which indicate the positions of the critical points. These are commonly designated as, A_1 (recalescence point); A_2 (lower temperature point of thermal retardation and cooling) on heating and cooling; and A_3 (upper temperature point of thermal retardation and cooling).

Table 1 gives the critical points as determined by the curves. For purpose of comparison, average points are given for pure

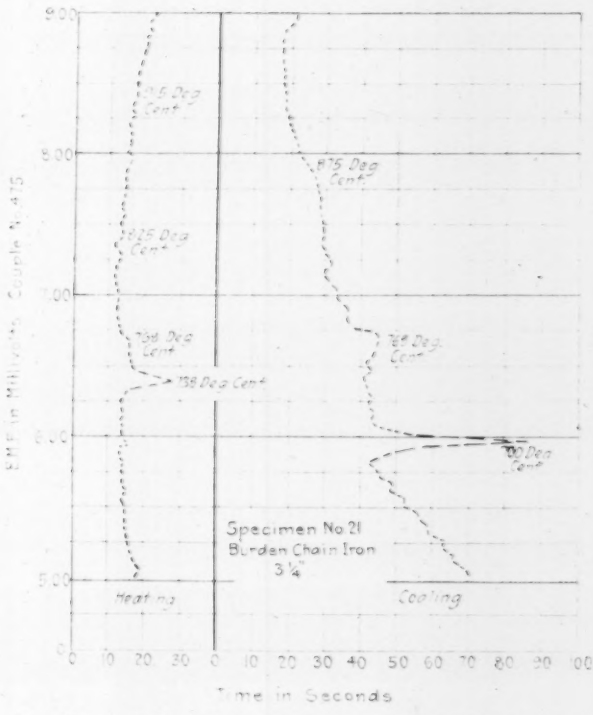


FIG. 6 TYPICAL HEATING AND COOLING CURVES FOR BURDEN IRON

iron and for iron of 0.10 per cent carbon and 0.20 per cent carbon, taken from Sauveur's diagram of iron-carbon alloys.

TABLE 1 CRITICAL POINTS FROM HEATING AND COOLING CURVES FOR BURDEN IRON

	—Burden stock.—		Average of Heating and Cooling, from Equilibrium Diagram.		
Critical Point.	Heating. deg. cent.	Cooling. deg. cent.	Pure Iron. deg. cent.	0.1% C. deg. cent.	0.2% C. deg. cent.
A^3	915	875	900	850	800
A^2	768	768	768	768	768
A^1	738	700	690	690	690

In the heating curve, which is the important curve in connection with heat treating, the indication of the upper critical point, A_3, is indistinct and, at first glance, apparently indeterminate.

But the small point shown at 915 deg. cent. was duplicated in size, shape, and position on all of the curves taken; as were also the indications of changes shown by irregularities of the curve from about 825 deg. cent. up to 915 deg. cent. It may therefore be concluded that the upper critical point is not sharp but extends over the range indicated, with a well-defined end at 915 deg. cent. This phenomenon is explained by the unequal distribution of the carbon in the iron, different parts of which vary in composition from pure wrought iron to 0.2

per cent carbon, as was determined by metallographic examination. The second and lower critical points are well defined at the temperature indicated.

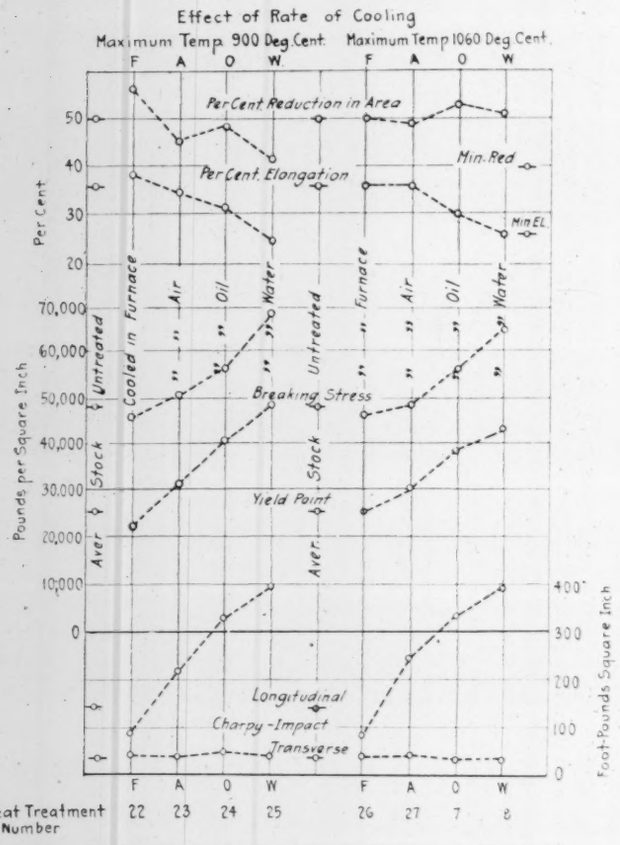


FIG. 7 EFFECTS OF DIFFERENT RATES OF COOLING

Specimens heated to 900 deg. cent. and 1060 deg. cent. cooled in furnace, cooled in air, quenched in oil and quenched in water. Results on untreated material shown vertically at the left and in the center. It may be readily seen: (1) that furnace cooling reduces the Charpy and tensile strength and increases the elongation and reduction of area; (2) that air cooling gives greater strength than the original material with less elongation and reduction of area; (3) that oil and water quenching increase the strength considerably. In the case of heat treatment No. 25 in which the specimens were heated to 900 deg. cent. and quenched in water, the tensile breaking stress was increased from the 49,000 average to 68,700, which is an increase of 40 per cent, and the longitudinal impact resistance was increased from 150 average to 406, which is an increase of 165 per cent. The effect of the rate of cooling on series (*b*), in which the specimens were heated to 1060 deg. cent., was generally less than in series (*c*), in which the heating was carried only to 900 deg. cent.

The practical conclusion from the location of the upper end of the upper critical range on the heating curve at 915 deg. cent. is that to anneal or air-quench the chain from above the critical range it should be heated to about 950 deg. cent., or about 56 millivolts (mv.) on the furnace thermo-couples, instead of 52 millivolts, or 890 deg. cent., as has previously been the practice in the manufacture of wrought-iron chain at the Navy Yard.

LABORATORY EXPERIMENTS IN HEAT TREATMENT

A preliminary study of heat treatment was made in the laboratory for the purpose of securing an indication of the best treatment to be used in the actual manufacture of the chain cable, and the effects of the following variables were studied:

1 Maximum temperature of annealing.

2 Rate of cooling, or quenching.

3 Drawing to different temperatures after heating to maximum temperatures, or after different rates of cooling.

4 Time of annealing, or time material is held at maximum temperature.

The list of heat treatments developed is given in Table 2. Each charge consisted of three tensile specimens and two blocks from which four longitudinal and four transverse Charpy specimens were machined. The furnace was heated to about 750 deg. cent. before specimens were introduced. The temperature was then raised, rapidly at first and slower as the upper limit was approached, to the point where the increase was about 5 deg. in 15 min.

TABLE 2. TABULATION OF HEAT TREATMENTS OF BURDEN IRON STOCK

Series (a): Rate of Cooling.

1 Heat to 900 deg. cent. and cool in furnace.
2 Heat to 900 deg. cent. and cool in air.
3 Heat to 900 deg. cent. and quench in oil.
4 Heat to 900 deg. cent. and quench in water.

Series (b): Rate of Cooling.

5 Heat to 1060 deg. cent. and cool in furnace.
6 Heat to 1060 deg. cent. and cool in air.
7 Heat to 1060 deg. cent. and quench in oil.
8 Heat to 1060 deg. cent. and quench in water.

Series (c): Rate of Cooling before Drawing.

9 Heat to 1000 deg. cent., cool in furnace, reheat to 900 deg., quench in oil and draw to 650 deg.
10 Same as (9) but quenched in water.

Series (d): Maximum Temperature before Cooling.

11 Heat to 800 deg. cent. and quench in water.
12 Heat to 850 deg. cent. and quench in water.
13 Heat to 900 deg. cent. and quench in water.
14 Heat to 950 deg. cent. and quench in water.
15 Heat to 1000 deg. cent. and quench in water.
16 Heat to 1050 deg. cent. and quench in water.

Series (e): Temperature of Drawing.

17 Heat to 1000 deg. cent., quench in water, draw to 550 deg.
18 Heat to 1000 deg. cent., quench in water, draw to 650 deg.
19 Heat to 1000 deg. cent., quench in water, draw to 750 deg.

Series (f): Rate of Cooling.

20 Heat to 1000 deg. cent., quench in oil.
21 Heat to 1000 deg. cent., cool in air.
22, 23, 24, 25 Series (*a*) Repeated.
26, 27 5 and 6 of Series (*b*) Repeated.

Series (g): Time of Annealing.

28 Heat to 970 deg., hold 1 min., cool in air.
29 Heat to 970 deg., hold 15 min., cool in air.
30 Heat to 970 deg., hold 30 min., cool in air.
31 Heat to 970 deg., hold 120 min., cool in air.

After the specimens had received their heat treatments as outlined in Table 2, the following tensile and impact tests were made upon the heat-treated specimens:

1 Tensile tests giving
- *a* Yield point
- *b* Breaking stress
- *c* Per cent elongation in 2 in.
- *d* Per cent reduction in area from 0.20 sq. in.

2 Impact tests giving
Resistance to shock in ft-lb. per sq. in. of an area of about 0.0785 sq. in. in a bar 10 mm. square by 55 mm. long, with 40 mm. between supports.

All tensile results were within 10 per cent of the average results from the three tensile specimens previously mentioned as having been subjected to heat treatments in each series. The averages are used in all plots.

The Charpy impact results varied greatly; in certain instances as much as 80 per cent from the average. For example, one specimen showed a fine, silky fibrous fracture with 321 ft-lb. per sq. in. resistance, and the next specimen, supposedly from the same bar, a coarse crystalline and dirty fracture with only 39 ft-lb. per sq. in. resistance (heat treatment No. 11).

These variations are probably due to variations in the character of the metal in different sections of the bar, as shown by the metallographic examination. It would be possible even for adjacent specimens to have widely different characteristics, and the probability of this is enhanced by the fact that the breaking sectional area of a Charpy specimen is only about 0.0785 sq. in.

The most important results of the tests are plotted in Figs. 7, 8 and 9.

As a general conclusion from the results of the physical tests, it may be stated that the iron is affected by heat treatment in a manner very similar to low-carbon steel, giving an increase of 40 per cent in the tensile strength and 125 per cent in the longitudinal impact strength when heated to 950 deg. cent. and quenched in water. This was confirmed by microphotographs showing sorbitic and martensitic structure typical of the hardening structure of mild steel.

It is therefore recommended that a further investigation be made of the effect of this heat treatment of chain cable, and the practicability of its application to the manufacture of chain cable.

It was suspected that the length of time during which the specimens remained at maximum temperature in the furnace might have some effect on the results, so a special series (*g*) was added of heat treatments Nos. 28 to 31, which were all heated to 970 deg. cent. and maintained at that temperature, for intervals of 1 min., 15 min., 30 min. and 2 hr. The results indicated that on specimens of that size the duration of the time of annealing has no appreciable effect.

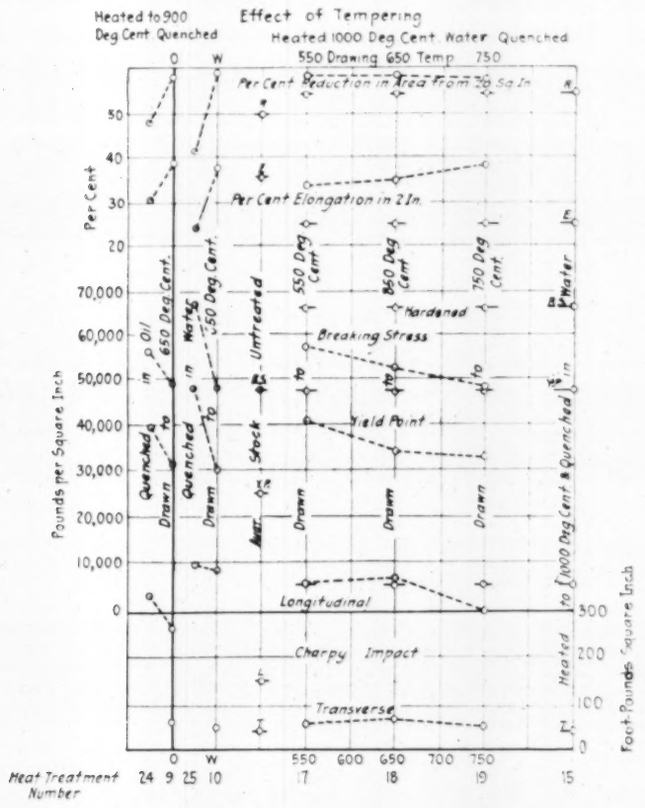


FIG. 8 EFFECTS OF HARDENING AND DRAWING

On the left is shown series (*c*), the effect of drawing to 650 deg. cent. of specimens heated to 900 deg. cent. and quenching in oil and water respectively. It is seen that the drawing brought the tensile breaking stress and elongation nearly down to the average untreated results, as shown in the left center of the sheet, while the per cent. reduction of area was greatly increased over the average stock results, and the reduction in the Charpy longitudinal strength was very small. On the right is shown series (*e*) all heated to 1000 deg. and water quenched, the abscissæ being the drawing temperatures, with the results of the undrawn given at the extreme right for comparison. The general effect of increasing the drawing temperature is to reduce the strength and increase the elongation. There is little change in the impact strength and reduction of area, which remain considerably greater than in the untreated stock results.

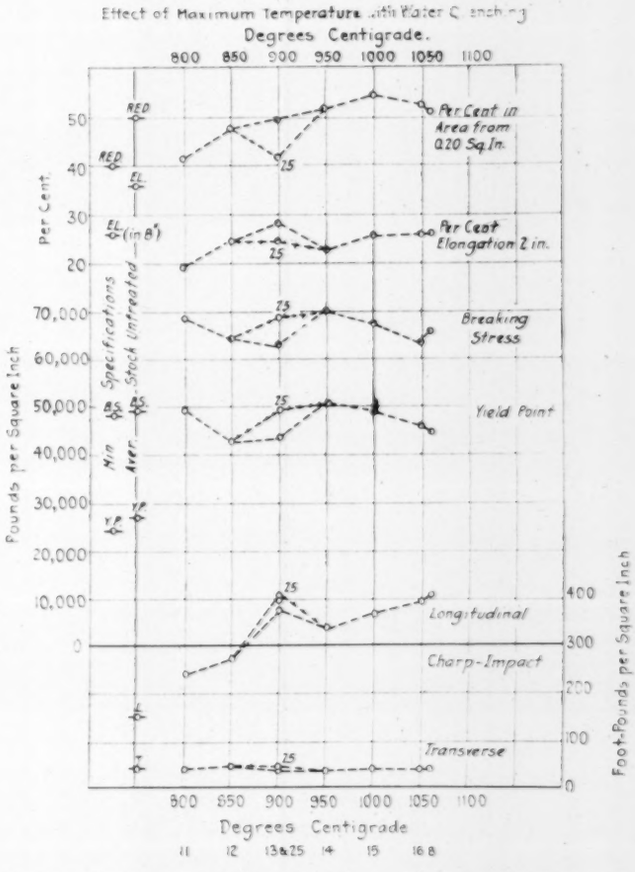


FIG. 9 EFFECT OF MAXIMUM TEMPERATURES OF HEATING WITH WATER QUENCHING

This comprises heat treatments Nos. 11 to 16, inclusive, in which the material was raised to different temperatures and quenched in water; and in addition heat treatments Nos. 8, 13 and 25. The two latter are the same and the difference in the results may be due either to the nature of the material, or to a slight variation in the heat treatment, as apparently there is considerable change near 900 deg. cent. It appears from these results that a temperature of about 950 deg. cent. would give the best results with water quenching, and any increase beyond 1000 deg. cent. gives less strength, although the Charpy longitudinal specimens gave best results at 900 deg. cent. and 1060 deg. cent. The data of the oil-quenched and air- and furnace-cooled specimens were not sufficiently complete to warrant plotting.

PRELIMINARY EXPERIMENTS WITH CHAIN LINKS

Two preliminary experiments were performed with full-size chain, (1) to confirm the results of the laboratory experiments as to the best temperature to which the chain should be heated for annealing by air cooling, and (2) to determine the best sequence of annealing and proofing.

It was concluded both from the investigation of the stock material and the laboratory experiments on this subject that the chain should be annealed from about 950 deg. cent. (56 mv.) instead of 890 deg. cent. (52 mv.) as hitherto had been the practice. To confirm this conclusion, 2⅝-in. Burden iron doublets were heated to temperatures corresponding to 48, 52, 56 and 60 mv. The tensile results from the specimens heated to 52, 56 and 60 mv. were not conclusive, but the fractures of the 56- and 60-mv. links, however, were, as a whole, very clean, fine and silky, and much better looking than those of the other links, and the practice has therefore been followed in the

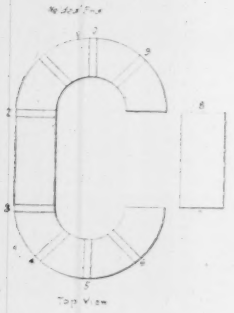


FIG. 10 LOCATION OF TEST SPECIMENS IN LINK

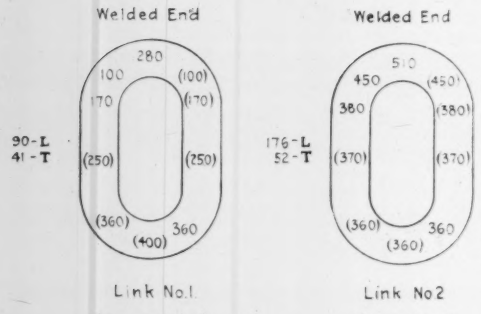


FIG. 11 GRAINS PER SQ. MM. AT VARIOUS SECTIONS OF LINKS 1 AND 2

manufacture of the chain, of annealing from approximately 950 deg. cent. (56 mv.), with the result that stronger chain has been produced, as determined by the routine test doublets referred to in the second paragraph on p. 193.

The second series of tests, to determine the best order to follow in annealing and proofing, was conducted with 2⅝-in. Burden-iron doublets. Chain may be (1) annealed before proofing, which is the regular practice, (2) annealed after proofing, or (3) annealed before and after.

When chain is proofed, it is strained well over the elastic limit of the link as a whole. For example, 3¼-in. test links are proofed to 367,000 lb., which leaves a permanent set of about ⅜ in. The ratio of proof to pulling load is 367,000: 620,000 = 0.59, while the ratio of elastic limit to ultimate stress of the material is 27,000:49,000 = 0.55.

Proofing therefore strains certain parts of the link above the elastic limit and leaves it in an internally strained condition. If method (1) is used the chain leaves the shop for service with internal strains, but if method (2) is used the internal strains of proofing are relieved by annealing, and from this consideration alone each link should be stronger.

Method (2) appeared to produce the stronger link. On the other hand, it must be noted that four of the six test doublets of method (2) broke by failure of the weld before they were strained to their breaking stress. One of the best men in the shop forged all of the links for this experiment, knowing that they were for experimental purposes. This, combined with the fact that there was only one failure of the weld in the tests made for each of the other methods, indicates that the failure of these four welds was due to the sequence of operations.

The logical explanation is that when a link is proofed before it is annealed there is a tendency to start an opening in the weld due to local strains which may have been produced by forging. Then when the link is subjected to an applied load it will break through the weld before the breaking stress of the material is reached. If the link is annealed before proofing, this condition will be relieved.

After four of the six doublets for method (2) broke through the weld, it was decided to run another series of tests on this method, for which purpose eight 2¾-in. doublets were used. Of these, two broke low with a dull, lusterless fracture, indicating overheating. The average of the other six was 504,000 lb., failing generally across the welded quarter with a fibrous fracture. In spite of the careful welding, the point of the scarf in one link was found not welded when pulled to destruction.

These results were compared with results from tests on 2¾-in. doublets annealed and pulled in the course of regular shop manufacture. These doublets were treated by method (1) by first annealing and then proofing.

The average pulling strength of six of these links was 482,000 lb., which, compared with the 504,000 of the links treated by method (2), shows that the latter process produces the stronger links, provided there is no injury to the weld due to the action of proofing on local strains.

Because this tendency to injure the weld does exist where method (2) is used, the conclusion was reached that method (1) of annealing before proofing should be followed and not method (2). Theoretically, method (3) would seem to be much preferable to both (1) and (2), since it combined the advantages of each, but the average breaking load was the same as for method (1). The fractures, however, were remarkably clean, pure, and silky. There would probably be a small advantage in using method (3), but it is not practical to go to the great additional trouble and expense of two annealing processes for the slight advantage to be gained.

DISCUSSIONS OF WELDING AND ANNEALING

In order to explain the failure of these power-forged, unannealed links and the way in which annealing restored their strength, it is important to understand the essential differences between hand and power forging.

The use of the steam hammer in forging enables a much greater reduction in area to be made at the weld, and hence produces a much greater amount of internal work. It also permits the use of a longer scarf, which necessitates a welding heat further around on the quarter of the link. In power forging, therefore, the link is brought up to a white heat around on the quarter, and then shades off through light orange, dark orange, and bright red, to a dull red at the bent

end. In hand forging the white heat does not cover so large an area and shades down to a dull red on the side of the link, and to black on the bent quarters and end.

It would be expected that these conditions would permit a greater crystal growth of the power-forged chain, except under the hammer at the welded end. Since the welded end of the power-forged link receives a much greater amount of work from hammering, it should have a much smaller grain size than the hand-welded link at the finishing temperature. On the other hand, the power-forged link has a greater cooling range during which the crystals may grow, since its finishing temperature is higher; but most probably this effect is small in comparison with that of hammering. The net results should be an appreciably smaller grain size at the weld of the power-forged link.

In comparison with the other parts of the same link, the grain size at the weld should increase from the middle to the end of the weld as the hammering effect decreases, and then should decrease from the weld around to the bend and in proportion to the maximum temperature to which the part was heated.

Hammering also deforms the crystals at the weld, but this effect should be obliterated by the crystal growth during cooling from 1200 deg. cent. down through the critical range, after hammering has ceased, and there should be no resultant "strain hardening."

The effect of the carbon content should further be considered. Above the critical range, carbon is present in the solid solution of iron, or austenite. As the metal after forging cools slowly in air through the critical range, all the carbon should separate freely from the austenite crystals in the form of pearlite. Therefore, carbon should have little hardening effect in either hand- or power-forged chains; and, since there is no practical difference between the cooling conditions of the two, it should cause no difference between them in hardening.

The only remaining difference between the structures of the hand-forged and power-forged links which could cause the greater stiffness of the latter, is in the grain size. In the side of the link where most of the stretching takes place, the grain size is probably somewhat greater in the power-forged link, while in the welded quarter, where the first power-forged links broke, the difference is probably not appreciable. According to Rosenhain, coarse structure generally does not affect tensile strength or ductility to a marked degree, although it does greatly decrease resistance to shock.

Therefore, from a theoretical consideration of the material as an alloy of iron and carbon only, we can find no apparent cause for stiffness in the power-forging process. In the tests which are hereafter described, however, it developed that in the power-forged link there was an overheated, distorted structure, which was relieved by the recrystallization in annealing. The stiffness of the link was undoubtedly removed primarily by relieving this condition, but also to some extent by the lessened hardening effect of carbon and the refinement of grain size caused by annealing.

TESTS OF FULL-SIZE LINKS BEFORE AND AFTER ANNEALING

For the purpose of testing, a shot of five 3¼-in. Burden iron links was forged in the regular manner and four of these were annealed. Specimens were cut from the unannealed link (designated as No. 1) and from one of the annealed links (designated as No. 2). The remaining three links were pulled. Ten sections were located around links Nos. 1 and 2, as shown in Fig. 10. Piece 7-8 was used for tensile specimens and Charpy specimens were cut from the straight section 2-3 and from the curved section 0-1.

A slice ¾ in. thick was cut from each of sections 0 to 6, and from 9, for metallographic examination. Eight specimens ¾ by ¾ by ½ in. were cut from each of these slices, numbered from 1 to 8, and their faces polished as required.

At the time the tests were started it was the practice to heat the chain to about 890 deg. cent. (52 mv.) and this value was used throughout. The present practice, as previously stated, is to heat to 950 deg. (56 mv.). The effect which this change might be expected to have on the results will be discussed later.

It should be noted that the tensile specimens, cut as they were from the side of the link, give a test of the material in that place only, and not of the material in other parts, nor of the strength of the link as a whole. It was impracticable to cut tensile specimens from the curved ends of the link, where the characteristics of the metal are modified by forging and where, also, the links usually fail.

Of the three links which were pulled, one broke across the welded quarter at a stress of 683,000 lb. The requirements for these links are: proof test, 376,000 lb.; and breaking load, 620,000 lb.

The results of the physical tests of the specimens are given in Table 3. In the third column are entered for comparison the results of tests on untreated stock material previously given. However, only a rough comparison can be made between these results and those from link 1, for the reason that in the link specimens there is a curvature of the slag grain with respect to the axes of the specimens, due to the curvature of the link. This curvature probably renders of no significance any difference under 10 per cent. The only marked difference is in the longitudinal Charpy tests, which gave results 45 per cent lower in the case of those cut from the side of the link, due to a combination of the effects of carbon and overheating in addition to curvature. The longitudinal specimens from the quarter gave somewhat lower results than those from the side, due to the effects of greater overheating, greater grain curvature, and larger grain size. The results of transverse specimens, as shown by the laboratory heat treatments, are generally contradictory and unreliable, and are therefore neglected.

TABLE 3 TEST OF UNANNEALED AND ANNEALED LINKS

	Average Results.		
	Link No. 1.	Link No. 2.	Stock Material.
Yield point, lb. per sq. in.	27,900	26,600	26,100
Tensile strength, lb. per sq. in.	47,600	45,500	49,000
Elongation, per cent	37	38	36
Reduction of area, per cent	51	55	50
Charpy tests, ft-lb. per sq. in.:			
Longitudinal, quarter	85	122	150
Longitudinal, side	90	176	
Transverse, quarter	48	41	39
Transverse, side	41	52	

In comparing the results of links No. 1 and No. 2, the question of curvature is of course eliminated, as the specimens from both links were in the same condition. Link No. 2 gives a small decrease in yield point and strength, and a small increase in ductility, which shows that annealing in air has lessened the hardening effects of carbon. Although annealing has also relieved the overheated condition and refined the grain size, these conditions do not have an appreciable effect in increasing the strength as shown by static tests.

In link No. 2 the longitudinal Charpy tests, side and quarter, were increased respectively from 90 to 176 ft-lb. per sq. in. (practically 100 per cent), and from 85 to 122 (almost 45 per cent), showing that annealing has greatly increased the resistance of the metal to shock, due mostly to relieving the

overheated condition and refining the grain size, which have a decided effect on ability to resist shock.

Comparing the results of link No. 2 to those of the laboratory experiment on Burden iron, which received the same heat treatment (No. 23), it is seen that the yield point, tensile strength, and Charpy results are smaller, and the ductility greater in the case of the link specimens. This indicates that a heat treatment applied to actual chain will not have as great an effect in changing the physical properties of the metal as it does when applied to laboratory specimens, on account of the much greater cross-section of the link, and of the mechanical treatment which it has received.

FIG. 12 LINK 1, WELDED END. FERRITE WITH TRACES OF PEARLITE, LARGE GRAIN SIZE, SLIGHT DISTORTION

FIG. 13 LINK 1, WELDED END. FERRITE AND PEARLITE (0.1 PER CENT C). MEDIUM GRAIN SIZE, SLIGHT DISTORTION

The foregoing tests lead to the conclusion that the present heat treatment of cooling in air slightly decreases the yield point and tensile strength, increases the ductility, and greatly increases the resistance to shock of the metal of the forged link.

GRAIN SIZE OF ANNEALED AND UNANNEALED LINKS

It was desired further to study the effect of the heating and hammering processes and of annealing upon the grain size of different sections of the links.

The average grain size for four of the metallographic sections of the link was estimated by the method of counting grain size which was described and recommended by Jeffries, Kline and Zimmer.[1] The results from links 1 and 2 are as follows:

Section.	Link No. 1.	Link No. 2.
0	280 gr. per sq. mm.	510 gr. per sq. mm.
1	100 gr. per sq. mm.	453 gr. per sq. mm.
2	169 gr. per sq. mm.	388 gr. per sq. mm.
6	359 gr. per sq. mm.	365 gr. per sq. mm.

It is not contended that these results are exact. In fact, they are probably not good to within 10 per cent, but it is stated with confidence that they give a very good rough comparison of the grain size of the various sections.

In Fig. 11 are sketches of links Nos. 1 and 2, showing the

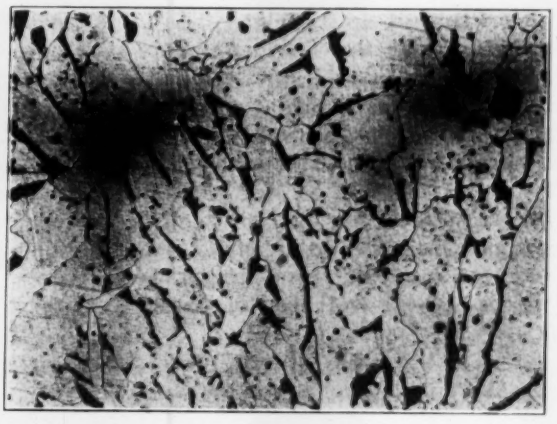


FIG. 14 LINK 1, WELDED QUARTER. FERRITE AND PEARLITE. MEDIUM GRAIN SIZE, MARKED DISTORTION

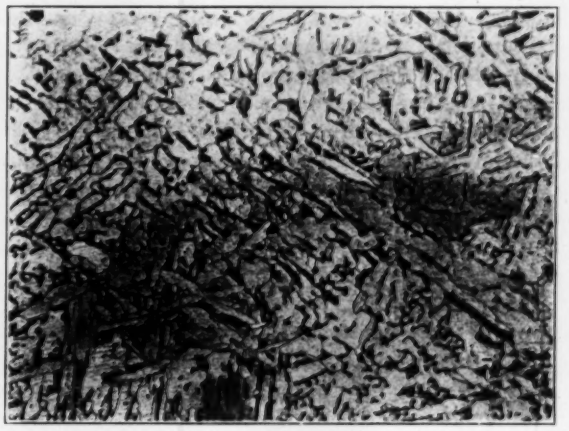


FIG. 15 LINK 1, WELDED QUARTER. FERRITE AND PEARLITE (0.15 PER CENT C). MEDIUM GRAIN SIZE, MARKED DISTORTION WITH ELONGATED FERRITE AND PEARLITE BANDS

grain size at the various sections. The determinations in the preceding table are indicated to the closest ten, without parentheses. The other figures, in parentheses, were obtained by induction as follows:

Since both sides of the link are in the same condition by similarity, section No. 9 should be the same as section No. 1, No. 8 the same as No. 2, and No. 4 the same as No. 6, and they are so indicated. The middle of the side of the link should have a grain size about half way between that of the welded and bent quarters, or about 250 gr. per sq. mm. for link No. 1, and 370 gr. per sq. mm. for link No. 2. From the decrease in

[1] The Determination of the Grain Size in Metals: Trans. A.I.M.E., Dec., 1915.

grain size toward the bent end of link No. 1, its grain size at the bent end is probably about 400 gr. per sq. mm. Since there is practically no variation in grain size away from the welded end of link No. 2, the grain size at its bent end is probably about the same as at the quarters, or 360 gr. per sq. mm.

In link No. 1 the grain size is fairly small right at the middle of the weld, but increases rapidly toward the quarter, since the effect of hammering on crystal growth then decreases faster than the effect of heating. But from the welded quarter to the bent end the grain size decreases again; since there has been no hammering and the temperature resulting from heating the link decreases as the distance from the weld.

FIG. 16 LINK 2, WELDED QUARTER. FERRITE AND PEARLITE (0.1 PER CENT C.) VERY SMALL GRAIN SIZE

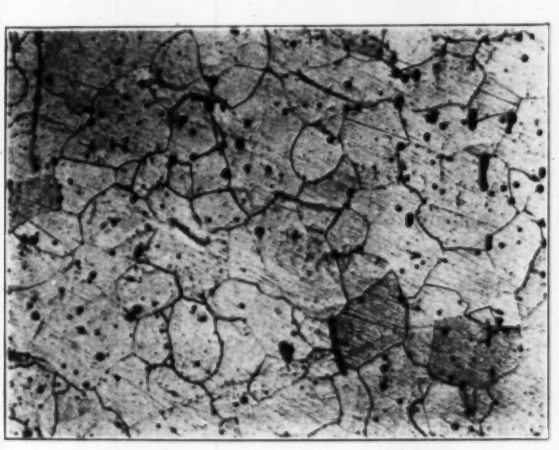


FIG. 17 LINK 2, WELDED END. FERRITE STRUCTURE. MEDIUM GRAIN SIZE

Comparing link No. 1 with link No. 2, it is seen that annealing has the effect of refining the grain size of the link, especially at the welded end. This gradation to a smaller grain size at the welded end shows that some effect from the smaller grains in that part before annealing still remains to produce a somewhat smaller grain after annealing, in spite of recrystallization.

CHARACTER OF STRUCTURE OF UNANNEALED LINK (NO. 1)

A microscopic study was made of the structure of the metal and its variation in different sections, and for this purpose both transverse and longitudinal faces of specimens from all parts of each link were examined.

In no section of link No. 1 is the carbon distributed homogeneously; it appears in segregated areas, except that near the boundaries of such areas the carbon has become somewhat diffused into the neighboring ferrite areas due to the various heats which the link had received during manufacture. The proportion of pearlite areas containing greater than 0.05 per cent carbon in different specimens varies from about 15 per cent to about 50 per cent, the average being about 30 per cent.

Typical areas from the welded end containing varying percentages of carbon are shown by Figs. 12-15. The notable feature is the distortion of the ferrite grains into elongated bands with angular bands of pearlite between them. This distortion is proportionate to the amount of pearlite in the area.

FIG. 18 LINK 2, WELDED END. FERRITE AND TRACES OF PEARLITE. SMALL GRAIN SIZE

FIG. 19 LINK 2, WELDED QUARTER. FERRITE STRUCTURE. VERY LARGE GRAIN SIZE

It does not, however, extend through all parts of the welded end. A large number of the specimens at this end show a normal or only slightly distorted structure, and in certain of them signs of slight burning were observed in the vicinity of the weld.

In the other sections of the link, away from the weld, there were no signs of distortion of the grains, and the pearlite had separated from the ferrite crystals in a perfectly normal manner. The smaller average grain size in the bent end of the link was clearly brought out by this examination.

CHARACTER OF STRUCTURE OF ANNEALED LINK (NO. 2)

In the annealed link the same unhomogeneous distribution of carbon was found, as would be expected. Around the

welded end, however, pearlite areas were relatively fewer than in link No. 1; other parts of the link were about the same as link No. 1. The possibility of this non-uniformity between the two links should have been avoided by insuring that both links were made out of the same bar, but the difference was not appreciable enough to affect any of the general conclusions which might be drawn from the experiment.

Typical areas from this link, with varying percentages of carbon, are shown by Figs. 16 to 19. The important point brought out is that there are no signs of distorted structure in any part of the link. The pearlite has separated and segregated around equi-axed grains in the normal manner. The average grain size is fairly uniform but is smaller in pearlite than in pure ferrite areas. Near the weld itself the structure was often very fine, as in Fig. 18, but away from the weld it would grow rapidly coarser, often to a grain size as large as that shown in Fig. 19.

EFFECT OF HEAT TREATMENT

From the foregoing examination, the conclusion is reached that the stiffness of the unannealed link is largely due to the overheated distorted structure in the welded end.

The fact that the metal of the forged link does not return to its normal condition during slow cooling after forging, even if it has been "overheated" to 1350 deg. cent., is probably to a large extent due to the effects of slag and other impurities. Annealing relieves this condition by the process of recrystallization, which practically wipes out all former structure and gives a finer and more normal grain size.

In regard to this overheating, Rosenhain says:[1] " . . . We find that by 'overheating' steel, i.e., by exposing it to unduly high temperatures, or for too long a time at any temperature above Ac_3, the growth of a very coarse iron structure results, and this, on cooling down, gives rise to a corresponding coarse ferrite-pearlite structure. Not only this, but the arrangement and forms assumed by the pearlite which is formed from such steel is characteristic; there is a strong tendency for the ferrite to take the form of straight bands with elongated and angular patches of pearlite between them, the ferrite bands frequently crossing one another, at angles of 60 deg. Such a coarse, sharply angular structure is, of course, extremely undesirable; there is a minimum of interlocking between ferrite and pearlite, and the straightness of the arrangement facilitates the propagation of slip or cleavage through the crystals. Such structures are, in fact, frequently met with in steel objects which have failed in service. Under test they generally exhibit some degree of weakness as regards shock and alternating stresses, but their tensile strength and elongation are frequently quite satisfactory. The most typical feature, however, is a decided drop in the yield point as compared with that of the same material in a more normal condition."

The above description fits exactly the structure which has been found in the carbon areas of the welded end of the unannealed link. In the results of the physical tests, it was seen that the shock-resisting quality of this link was actually low, but it appears that the tensile strength and elongation are not "quite satisfactory" as indicated in the foregoing quotation.

[1] Introduction to the Study of Physical Metallurgy, pp. 281-282.

CONCLUSIONS

For heat treating, Burden iron should be heated to about 950 deg. cent. (56 mv.) instead of 890 deg. cent. (52 mv.), which was the former practice.

There is no apparent relation between character of fracture and character of structure.

Heating to 950 deg. cent. (56 mv.) for cooling in air gives stronger and better chain than heating to lower temperatures, and heating to higher temperatures gives no improvement.

The present procedure of annealing before proofing should be continued.

Stiffness of the unannealed link compared with the annealed link is mainly caused by overheated distorted structure at the weld.

Annealing removes stiffness of the forged link by relieving overheated distorted structure. It decreases the tensile strength and yield point, and increases the ductility and resistance to shock, of the metal; but it increases the strength, as well as the ductility and resistance to shock, of the link as a whole.

The laboratory experiments indicate the following conclusions:

(1) *Rate of Cooling.*

Cooling in furnace:

Reduces tensile strength from 49,000 to 47,000.
Reduces impact resistance from 150 to 90.
Increases elongation and reduction of area.

Cooling in air:

Increases tensile strength from 49,000 to 50,500.
Increases impact resistance from 150 to 240.
Reduces elongation and reduction of area.

Quenching in oil:

Increases tensile strength from 49,000 to 57,000.
Increases impact resistance from 150 to 340.
Reduces elongation from 36 to 31 per cent.

Quenching in water:

Increases strength from 49,000 to 67,000.
Increases impact resistance from 150 to 400.
Reduces elongation from 36 to 25 per cent.

(2) *Temperature from Which Cooled or Quenched.* Increase of temperature above 950 deg. cent. slightly decreases tensile strength, increases elongation and reduction of area, and does not appreciably affect impact resistance. Temperature of 950 deg. cent. gives best results.

(3) *Drawing Effect.* The higher the drawing temperature, the greater the decrease in tensile strength and increase in elongation. Drawing has little effect on impact resistance.

(4) *Increased Time of Annealing* slightly decreases tensile strength, and slightly increases elongation, reduction of area, and impact resistance.

SIX YEARS' DEVELOPMENT OF THE WERKSPOOR MARINE DIESEL ENGINE

By THOS. ORCHARD LISLE, NEW YORK, N. Y.

Member of the Society

THIS company has completed 37 propelling engines for 24 sea-going mercantile ships, representing about 36,000 hp. Werkspoor was one of the first firms to build Diesel-type engines on an extensive scale. Our first attempt at building the machinery of motorships was most modest. It was recognized that problems would arise which no ship tests or stationary-engine experience could foresee. Throughout we have remained steadfast adherents to the four-stroke cycle and have no reason to regret it. We also decided that unless an engine can be repaired in any port where steam engines can be repaired, it is of no use for ocean-going ships; consequently there is nothing fantastical about our designs, they are exactly similar to an ordinary steam engine.

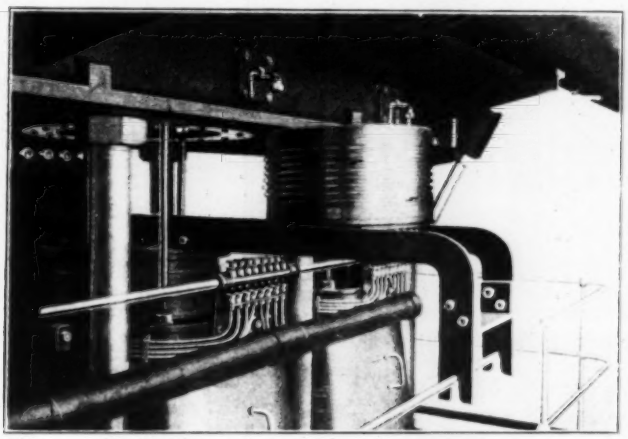


FIG. 1 IMPROVED METHOD OF REMOVING AND REPLACING PISTON (PATENTED)

It was the *Vulcanus* that gave us the real experience, as this was the first sea-going full-powered ship, and her engine was the first Diesel to have short pistons, crossheads and guides. She is a ship of 2080 tons displacement and 1235 tons deadweight capacity fitted with a six-cylinder direct-reversible Werkspoor crosshead engine of 450 b.hp. at 160 r.p.m. Her fuel consumption did not exceed two tons per day, or one-fifth of the coal consumption of a steamer of similar cargo capacity. She was placed in service in 1910. At the beginning, trouble was experienced partly through lack of experience of the ship's engineers and partly through her air compressors, but the engines gave very little trouble indeed, wear and tear of the moving parts being very slight, and less than is usually found with marine steam engines. After two years' wear the cylinders were opened up and gaged as shown in Table 1.

On one occasion a high-pressure air reservoir burst while the engines were being overhauled at Amsterdam. Bad welding had left a fracture and the top part of the compressed-air bottle blew off. The indirect cause was the accumulation of water in the air retainer, which had not drained owing to a cracked internal pipe. This mishap taught us to dispense with the welded-type air bottles, also to suspend high-pressure bottles with covers and valves downward, thus effectually preventing any unknown accumulation of water.

TABLE 1 GAGING OF MAIN MOTOR CYLINDERS OF THE "VULCANUS" AFTER TWO YEARS' WEAR

Original Size 400 mm. (15⅞ in.)

Cylinder No.	Top.	Middle.	Bottom.
1	400.5 mm.	400.4 mm.	400.1 mm.
2	400.6 mm.	400.4 mm.	400.1 mm.
3	400.8 mm.	400.6 mm.	400.6 mm.
4	400.7 mm.	400.4 mm.	400.5 mm.
5	400.6 mm.	400.4 mm.	400.2 mm.
6	400.4 mm.	400.3 mm.	400.15 mm.

For several years we have not tested our high-power engines in the shops, but since the war the engines of new ships have had about three hours' running at the wharf and about four hours' at sea. This may surprise some Diesel engineers and probably many will hardly agree with me that a fictitious value has grown round the tests made on the floors of builders' works.

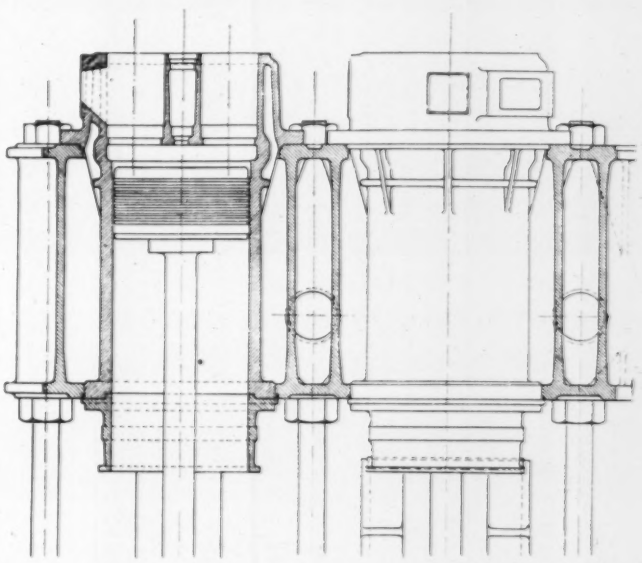


FIG. 2 SECTION OF CYLINDER, ILLUSTRATING HOW THE WATER COOLS HOTTEST PART OF COMBUSTION CHAMBER

Certainly, some of the faults of a new design can be made to appear by shop trials, but when the design has been standardized, the tests are but little more than a check upon the quality of the machine and fitting work.

For years the detachable-cylinder-head design has been the standard practice with virtually every make of Diesel engine both marine and stationary, and still is the recognized standard practice. At the cylinder head, just level with the combustion, that is to say, where cooling is most needed, there are few or no cooling water passages. In the design adopted after the *Vulcanus*, there is therefore a complete water passage round the sides as well as on top of the combustion chamber. Expe-

From an Illustrated Review given at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, December 1916.

rience with the *Vulcanus* also showed that when using a very heavy oil the rings are apt to become gummed and then stick. So in our next engine, overhauling the pistons was greatly facilitated by the introduction of a patented device by which a piston can be dismounted from below in about 30 minutes, piston rings replaced, and the pistons remounted in about 1½ hours without disturbing any pipes or operating mechanism.

Radical changes in design were made with the engine in the tanker *Juno* in 1912. The frames for supporting the cylinders were entirely dispensed with, and forged-steel columns substituted, stiffening being obtained with and lateral stresses absorbed by diagonal steel rods. The load of tension that these rods have to take is over 130 tons per cylinder, or about 780 tons for the sixteen rods of the whole engine. Although there are cast-iron columns at the back of the engine, they are not secured to the cylinders, but have a sliding-surface fit and carry the crosshead guides; also, being hollow, they are utilized as intercoolers for the air compressors. They allow an up-and-down movement of the cylinders, but side pieces prevent lateral motion.

The open-column construction has been so successful that all our stationary engines are now designed in this manner.

With the later models the fuel-injection valve is offset from the center, and there is at least a space of 4 in. for cooling water everywhere in the cylinder head. Offsetting this valve, in contradiction to all theories, is proving entirely successful in actual practice. As the supporting webs of the cylinders occasionally cracked, our designers dispensed with them entirely in later designs and also improved the shape of the cylinder head. Since these various alterations in cylinder design have taken place, absolutely no cracks have occurred. This engineers will be glad to learn, and it will do much to allay the prejudice that still exists in some quarters against the marine Diesel.

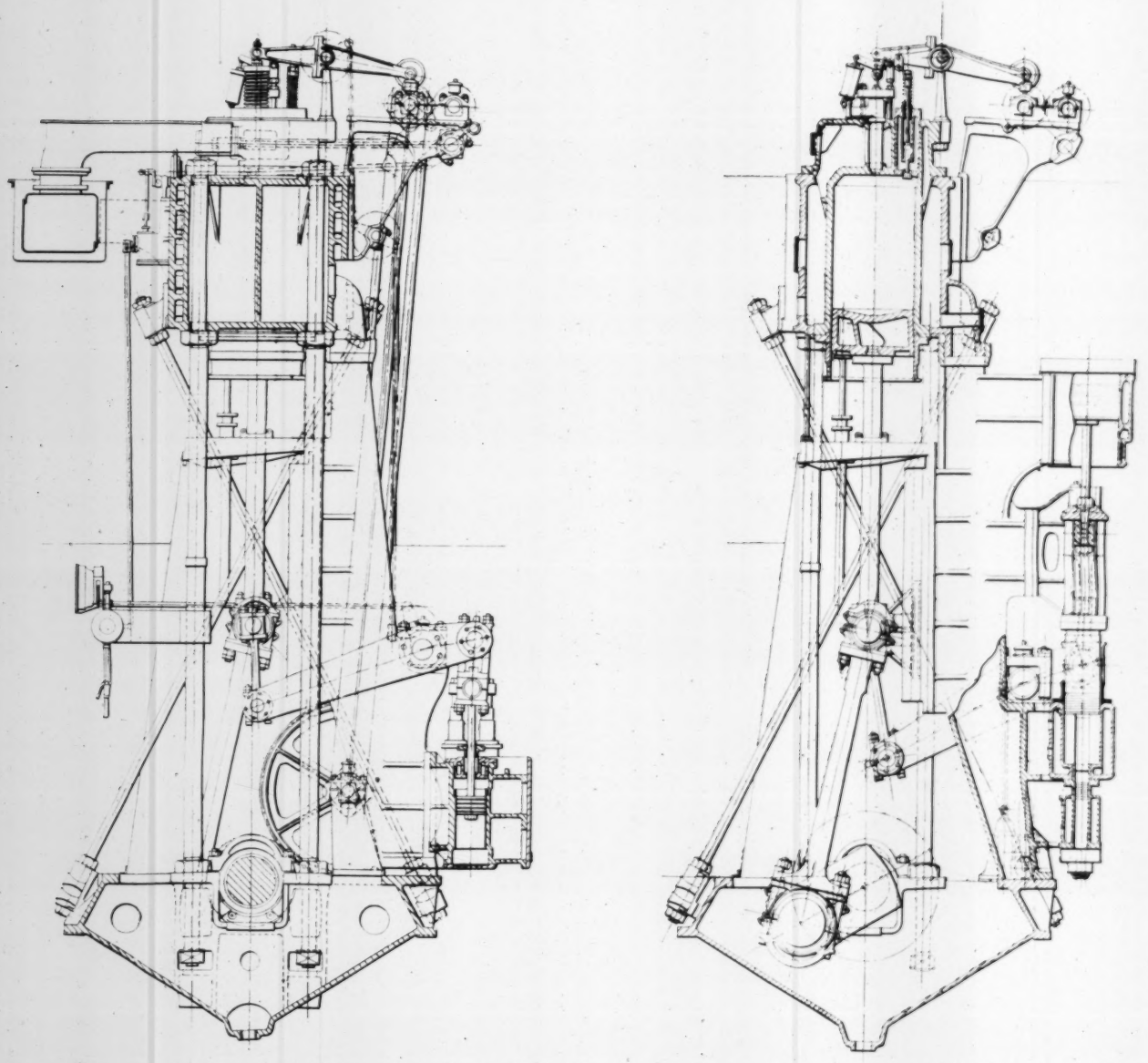


FIG 3 ENGINE OF THE EMANUEL NOBEL. THIS IS THE TYPE BEFORE THE LATEST IMPROVEMENTS, AS STATED IN THE TEXT, WERE MADE

With regard to piston cooling, all our ships now use sea water for cooling the cylinders, pistons and bearings, there not being sufficient troubles to necessitate a change to fresh-water cooling. With sea water below 100 deg. fahr. practically no scale is deposited. When it is below 70 deg. fahr. it is as good as fresh water. But pistons and cylinders must allow of no

pockets; once scale or dirt starts to deposit, it quickly accumulates and so causes local temperatures.

Our present system consists of a jet of water forced up through clearance tubes, having no rubbing parts, but moving up and down with the piston to prevent splashing. The piston is never more than about half-full of water, the broken surface of the water being far better for the cooling than a solid mass. By means of a simple sight system a chokage of water supply at any point can be detected instantly.

So far as our company is concerned, the trouble with air compressors is absolutely a matter of past history. In the air-compressor system that has replaced the type recognized, the link-and-beam-operation motion is still retained, as this has proved efficient with all the ships. The high and middle stages are arranged side by side, each having its own piston rod, while the first stage is directly below and also has its own piston rod; thus every piston can be separately dismounted. All valves are interchangeable.

In the earlier ships some crankshaft failures have occurred, and crankshafts constructed by the same makers and installed in other ships gave out in the same manner. As a precautionary measure we have lately increased the size of bearings and have installed forced lubrication for the main bearings. For some vessels now building, built-up crankshafts are being adopted.

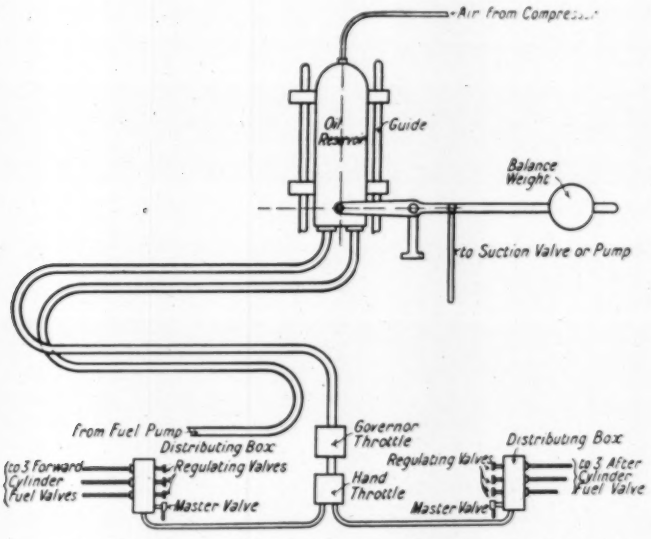


FIG. 4 FUEL-OIL CONTROLLING AND DISTRIBUTING SYSTEM

A smart ship's engineer can reverse in 5 seconds a 1000-hp. engine from full ahead to astern, but 7 to 10 seconds is the usual time occupied. For the purpose of obtaining the reverse motion there are two camshafts, one for the ahead running and one for the astern movement, and the astern camshaft is driven by means of a spur gearing from the ahead camshaft. These two shafts are mounted on sliding brackets or saddles. When maneuvring, these brackets, by sliding to and fro, bring the ahead or astern cams under the rolls of the valve rockers. By making the rockers unusually large, the angle of the face of each roller, where it meets its cam, is never steep, and this produces smooth and silent running. Thus reversings are rapidly and quietly carried out. The cams and cam rollers are of cast iron, and never have I seen the slightest sign of wear in them, even with a four-year-old ship. The steel tubes have a saw cut down through the center, the two halves being held apart by cross-struts to eliminate vibration.

Most Diesel engines have a separate fuel pump to each cylinder. This method requires too delicate adjustment to supply exactly the quantity of fuel to each cylinder. So a single pump is fitted which supplies two distributing boxes, each box having feeds to three cylinders and every feed its own adjuster. To the exhaust branch of each cylinder is fitted a thermometer by which the engineer can instantly see if any one cylinder is receiving more or less fuel than the others. As a stand-by, an extra pump with a single change-over device is fitted. The fuel pump feeds a reservoir in which an air pressure is maintained, thence the oil passes through a governor-controlled throttle, a hand throttle, and through master valves, and finally into the distributors. The receiver holds enough fuel to run the engine for 15 min., so that in case of a breakdown of the fuel pump the spare pump can be connected up before the engine stops. The distributing boxes are quite close to the indicator cocks, so that adjustment can be made by the engineer in charge while he is reading the cards and thermometers. The plunger fuel pump is made from a solid steel forging; the valves are simply steel balls, and the gland runs in an oil bath. This system was adopted with the earliest ships and has been retained with all since built.

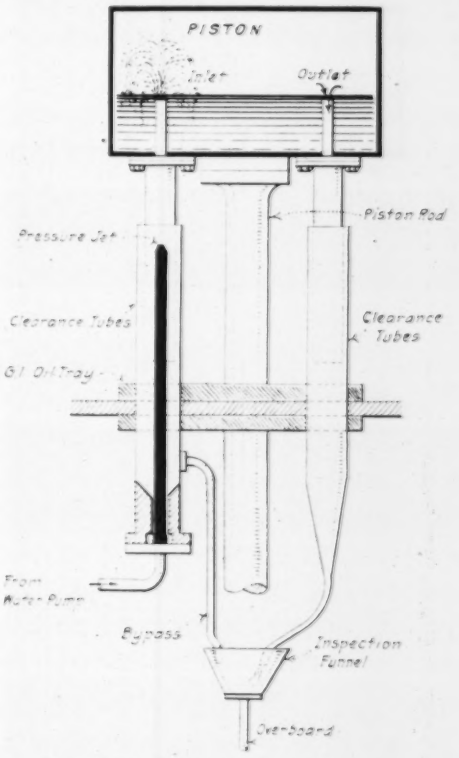


FIG. 5 PISTON-COOLING SYSTEM

At sea the waste exhaust gases of the main engines are utilized to fire a donkey boiler for the ship's auxiliary machinery. This has been most successful and we have since been followed by other shipbuilders. Specially large heating surfaces must be given to the boilers, the temperature being 700 to 800 deg. fahr. compared with 2000 deg. fahr. in the furnace flues of an ordinary oil-fired steam boiler. On the *Emanuel Nobel* and *Elbruz*, sister ships of 6500 tons d.w.c., on a displacement of 9000 tons and with cargo capacity of two million gallons of oil, the auxiliaries are a steam-driven dynamo, a steam-driven spare compressor set, a 7-hp. semi-Diesel, Brons type oil-engine-driven dynamo, and the usual steam-operated pumps. The donkey boiler has two furnaces and the exhaust gases from the two main engines are led

through one furnace and supply sufficient steam for operating the auxiliaries, including the steam gear. The other furnace is used at night for oil-fired burners as, more work being required of the dynamo, not so much steam is available for steering. In the daytime at sea no oil firing is required, for as much as 120 lb. pressure can be maintained with the exhaust gases alone, but usually about 100 lb. is the average pressure maintained. With the *Emanuel Nobel* the recorded fuel consumption for all purposes per 24-hr. day is 9 tons of gas oil—8¼ tons for the main motors and ¾ ton for the boiler. This gives 0.29 lb. per indicated horsepower per hour under average running conditions. The total consumption, including auxiliaries at night, works out at 0.32 lb., per indicated horsepower

has resulted in being among the most successful of all our installations.

The reversing propeller has been developed and used with four recent full-powered ships, including the *Poseidon*. Several objections may be raised but they will be founded mostly on the prejudice formed by the indifferent services given by reversible propellers, cheaply built and poorly constructed, for the operation of small motorboats. Our mechanism is entirely different. Power to reverse and actuate the mechanism is furnished by the engine itself. By interconnecting the throttle directly with the propeller mechanism, the strokes of the fuel pumps are automatically reduced and increased by the mere act of throwing the blades into the central position, or by

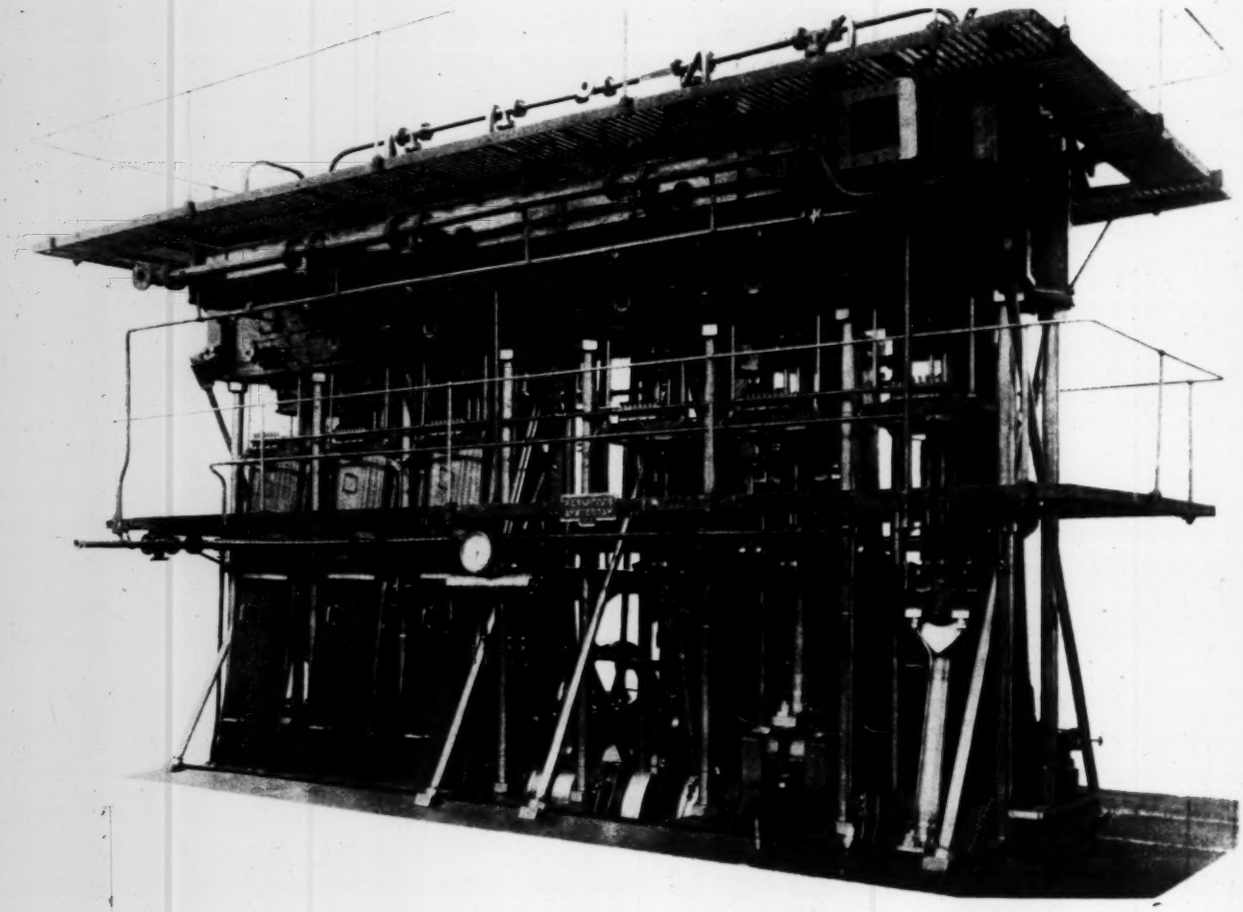


FIG. 6 FOUR-CYCLE-TYPE REVERSIBLE MARINE DIESEL ENGINE (1020 B.HP., 1360 I.HP. AT 120 R.P.M.). WEIGHT 122 TONS. FUEL CONSUMPTION UNDER 4½ TONS PER 24-HOUR DAY

per hour. An oil-fired steamship of the same power would have a consumption nearly four times as great, while an oil-fired steamship of the same cargo capacity and of the same speed (11½ knots) would have a total fuel consumption five times as great, because her engines would have to be of greater power, owing to the required displacement being about 800 tons greater. Under present abnormal shipping conditions, by the way, the greater carrying capacity of a motorship on a given displacement is even of greater importance than its fuel economy.

With slow-speed, heavy-duty crosshead engines of 200 to 500 hp. at 160 to 200 r.p.m. we have taken a bold step that may make many marine steam and oil engineers shake their heads; but the machinery with which this step has been taken

reversing them respectively. One important advantage is that the ship can go ahead and astern a hundred times in an hour without the use of compressed air, so that the engine will not be *stalled* at the critical moment owing to lack of starting air. How important this is with a harbor tug can be easily understood. Besides, the navigator on the bridge is given complete control of the ship's movements by a small handwheel installed on the bridge. The reasons for such a radical step may be enumerated as follows:

1 Simplification of main engine due to absence of reversing features
2 Reduction in power and quantity of auxiliary machinery
3 Rapid and independent maneuvring
4 Reduction in first cost of machinery.

Because of the strain thrown on the machinery by reversing the direction of a large ship, the tackling of the reversible propeller is by no means a simple matter; but every part, being massive, has proved more than capable of handling the power, without showing noticeable wear. The fact that the owners of the *Poseidon* ordered other similar ships after it had been in service for some time, is evidence that the reversible propeller is satisfactory in practice.

Since this paper was written I have received cabled permission to give drawings and details of our new submarine engine. The motor shows a remarkable advance in design and construction and is perhaps the most simple Diesel engine ever built. On the test bed at Amsterdam there is now a six-cylinder set designed to operate at 400 to 450 r.p.m. on the four-cycle principle. It can develop 500 b.hp. when running at 400 r.p.m., and is capable of a considerable overload. It only weighs about 12 tons without flywheel, which, I believe, is lighter than any existing two-cycle Diesel submarine engine of similar power. An entire cylinder may be removed and another substituted in about two hours, while a piston can be taken out and inspected in about 15 min. It has very few cast parts, the only castings of note being the cylinder boxes, the cylinders, the pistons and the air-compressor cylinders. Instead of cylinders of the ordinary type there is a long cast-iron box running the length of the engine into which the cylinders are placed from below and held in position by a flange, the cylinder and cylinder head being in one, which gives a very large water-cooling space over and around the combustion chamber. This cylinder box is connected to the bedplate by steel rods 3 in. in diameter, thus taking all strains from the bedplate, and consequently each bearing is suspended directly from the cylinder, which enables the bedplate to be made from light cast-steel bearing blocks connected by cast-steel girder beams along the engine, thus dispensing entirely with cast-steel, iron or bronze bedplate. To collect the oil from the working parts, the bottom of the engine is enclosed by a steel plate 1⅛ in. thick. The running gear is entirely enclosed by steel plates which are easily detachable. Each working

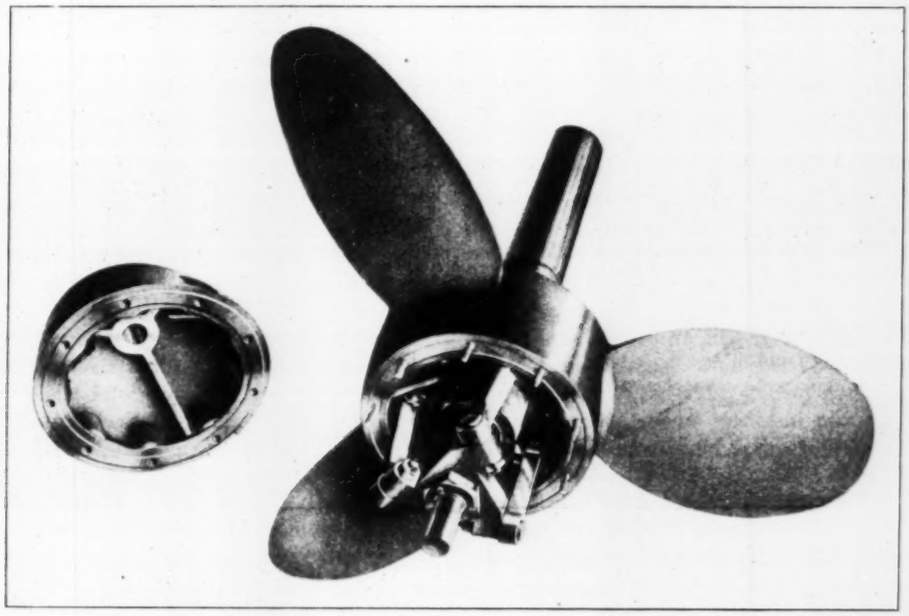


FIG. 7 REVERSING-BLADE PROPELLER

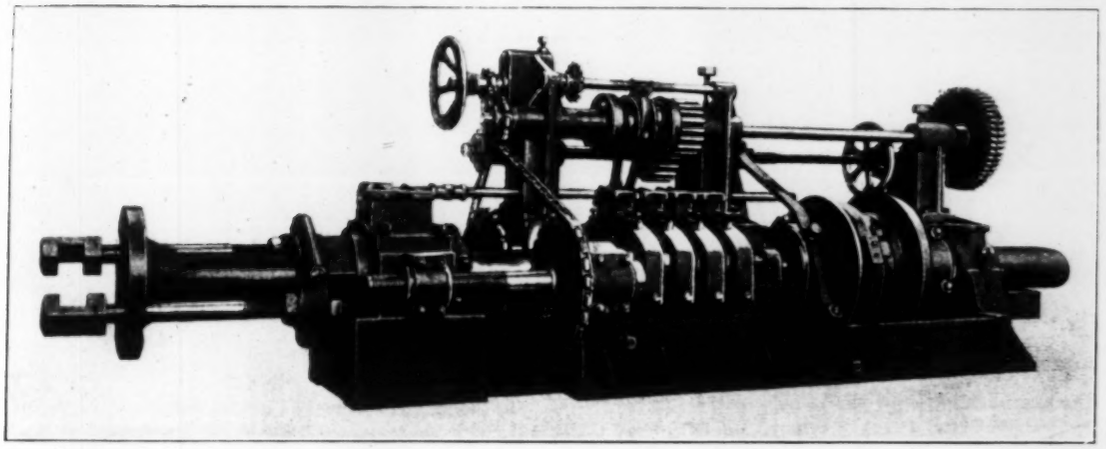


FIG. 8 MECHANISM AND THRUST BLOCK FOR OPERATING REVERSING-BLADE PROPELLER

cylinder is made in two parts, the upper part being cast in one piece with the cylinder head, while the lower part is detachable and enables the pistons to be removed very quickly. This extension also is water-cooled, a sheet-metal band being placed entirely around it. An innovation is to be seen in the blade steel springs for closing the valves, which give less vibration and take less height: and only three springs are required for two cylinders. It is not necessary to water-cool the pistons with this size of engine; but some sort of cooling device is advisable, so the air aspired by the down stroke of the main piston is drawn by suction through the cylinder box from the upper part of the crank case and is replaced by cool air blowing through the bent pipes. In order to overcome the valve difficulty sometimes experienced with air compressors, we designed a special valveless three-stage compressor, and this is situated at the forward end of the engine. The three stages are driven by three cranks having angles of 120 deg. to each other. Each cylinder has inlet ports at the bottom, and the low-pressure and middle-pressure cylinders have an outlet hole at the end, while the high-pressure cylinder has an outlet valve at the top where it can easily be taken out if necessary. Thus there is only one valve in the entire compressor.

My personal opinion is that in six or seven years every new cargo ship of under 10,000 tons displacement will be equipped with internal-combustion engines of the crude-oil type, except in a few rare instances where special circumstances of service will cause steam engines to be the only suitable machinery. The advantage of the Diesel-type engine will be appreciated most during normal times. When low freight rates return, it will not be possible for steamers to compete with motorships on many routes, particularly where long distances have to be covered, and especially where tramps are concerned. In hard times shipowners will be forced to use the most economical propulsion. Other methods of steam power cannot be made as efficient and as economical as the crude-oil engine, unless the price of oil should rise to phenomenal figures.

DISCUSSION

A. J. WOOD said that with regard to the author's remark that one particular type of four-cycle Diesel engine was lighter per horsepower than the same capacity unit of a two-cycle, he would like to ask whether there was any particular design followed to effect the result, and whether there were other types of engines that had effected the same results. Mr. Lisle replied that in marine work the four-cycle engine was lighter, owing to the additional parts necessary for the two-cycle, particularly the scavenging pumps. Theoretically the two-cycle should be much lighter, but on those put to service the two-cycle engines had been heavier than the four-cycle. That included the compressor of the engine. There were no scavenger pumps with the four-cycle engine, and that saved an immense amount of weight.

JULIUS KUTTNER, with reference to reversible propellers, asked about the fact that the blades on solid propellers frequently broke, and separate solid blades were always carried on the deck of the ship. If the solid one broke off, were not the chances of breaking in the reversible propeller much greater? Mr. Lisle replied that he did not see why it should be so. They might break off if they hit anything, of course, but they could be replaced just as easily, and it was possible to make them just as strong, this being a question of design more than anything else.

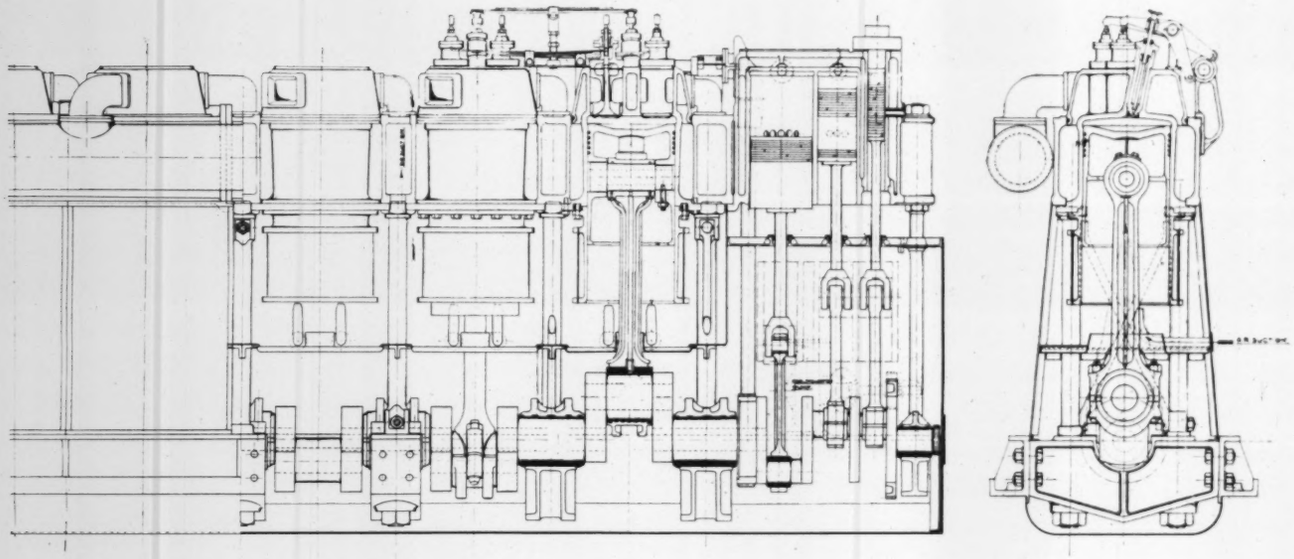


FIG. 9 SUBMARINE DIESEL-TYPE ENGINE. THERE IS ALSO A DESIGN OF SMALLER POWER IN WHICH THE WEIGHT HAS BEEN REDUCED TO 31.5 LB. PER B.HP.

THE DOWNFLOW TYPE OF STEAM BOILER

By JOHN CLINTON PARKER, PHILADELPHIA, PA.

Member of the Society

THE downflow principle is shown diagrammatically in Fig. 1. The reservoir has separate compartments for water and for steam, with a swinging valve between, which automatically forces water into the tubes to replace that which is discharged by each drop in pressure. The straight water tubes are arranged in the form of flattened-coil elements leading downward from the water compartment with direct connections from the bottom ends to the steam compartment. A check-valve at the water-inlet end of each element prevents reversal of the flow.

The water is maintained at a given level in the lower compartment of the reservoir through a feed connection in the regular way. It flows downward by gravity into the elements and seeks the same level in the upcast. When heat is applied, the water in the upcast is soon discharged into the reservoir by the expansion of the steam formed in the lower tubes. The water then runs down from the reservoir to regain its level in the upcast. This is frustrated by continuous evaporation, mainly in the lower tubes. The more the fire is forced, the greater is the proportion of steam in the upcasts, the larger is the unbalanced head of water, and the more rapid is the flow through the tubes.

A 20-hp. downflow boiler enclosed in a steel casing was built in 1899 at Roach's shipyard in Chester, Pa. There were three drums 10 in. outside diameter, 3 ft. long, 160 tubes 1 ft. outside diameter by 3 ft. long, and 36 firebox tubes $1\frac{1}{2}$ and $1\frac{3}{4}$ in. The headers consisted of a pair of cored tube sheets with cored cover plates which when bolted to the tube sheets formed return bends, the idea being that the one large outside joint would obviate a lot of inside ones, a steam-tight joint not being essential between the inside ribs. Experience with this boiler, however, led to the development of the two-tube junction box and the use of larger tubes.

STANDARD DOWNFLOW BOILER

Fig. 2 shows a standard design. The drums are constructed in accordance with the best practice, using high-class material and workmanship. The longitudinal seams are butt-strapped and triple-riveted, giving very high efficiency.

The diaphragm of $\frac{1}{4}$-in. steel plate is riveted to the shell and arranged to form a pocket at the front to collect the scale discharged from the tubes. The anti-priming valve is hinged to the diaphragm head and serves as a manhole for the lower chamber. The bottom of the drum below the level of the nipples leading to the elements forms the sediment pan or mud drum. An inverted angle with closed ends is placed over the blow-off opening, making the blow-off effective over considerable area.

The elements are formed by expanding the tubes into the junction boxes which hold two tube ends, with a handhole opening opposite each.

The tubes in the upper pass form the feed element or economizer, which in this unit is 16 tubes wide and three tubes high. The top end is connected to the drum with an expanded nipple, and the feed connection is in the junction box at the front end of the first tube in the element. At the rear end of the tube is placed a non-return valve, which prevents the feed going the wrong way and entering the drum through the inlet connection.

The flow in the economizer element is forward and back alternately through each tube in the top row, then down to the next row, and so on, finally discharging through a vertical upcast into the rear drumhead above the diaphragm. When the feed is shut off, the drum connection furnishes the economizer element with a circulation.

The lower or evaporating elements are two tubes wide, passing the water twice across the furnace at each level. The connection from the drum to the upper or induction end is made by an expanded tube entering an "inlet" box which supplies two elements. Each element has a non-return valve, located

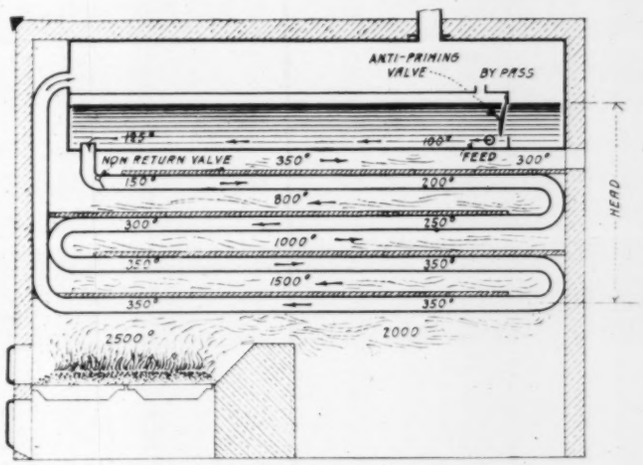


FIG. 1 EVAPORATION DIAGRAM ILLUSTRATING DOWNFLOW PRINCIPLE

in the inlet box. The valve fits into the tube end and is held in place by a loose pin, which forms a positive stop when the handhole is closed. The valve is loosely hinged with plenty of clearance, and is easily removed through the handhole for cleaning. The lower end of each element is connected to the steam chamber by an independent upcast. The arrangement of the tubes permits the free and independent expansion of every tube without strain on any joint.

The large swinging valve at one end of the water compartment closes as often as steam is withdrawn through the steam opening with sufficient rapidity to lower the pressure. In practical service, pressure changes are more or less frequent, sudden and pronounced, according to the irregularity of the service and the severity of the demands for steam. In such service as supplying steam hammers, rolling-mill engines, electric-power plants, subject to sudden heavy peak loads, or warships which may require full speed on a moment's notice, the steam pressure may be suddenly lowered 10 or 15 lb., or even more, in a very short space of time. In every such case a quantity of water, proportionate to the drop in pressure and the speed with which it takes place, is discharged from

Abstract of paper presented at the Annual Meeting of the AMERICAN SOCIETY OF MECHANICAL ENGINEERS, December 1916. Pamphlet copies of complete paper may be obtained. Price 10 cents to members; 20 cents to non-members.

the tubes of any type of water-tube boiler by the sudden evaporation due to the lowering of the boiling point along with the pressure.

Under conditions of a drop in pressure causing displacement of water from the tubes, a bypass controlled by a float-operated double-beat valve equalizes the pressure.

The double valve just referred to may be seen in Fig. 2 over the swinging valve. It is balanced and operates without touching the sides of the bypass openings through which the disks move. Sufficient clearance is provided as a vent to allow the water compartment to fill to the water level under normal conditions. When a pressure drop occurs with sufficient suddenness to affect the circulation, the anti-priming valve closes. The excess pressure forces water into the tubes until the float opens the bypass. This releases the pressure and allows the water compartment to fill, and the operation is repeated intermittently as long as the pressure continues to fall. The prompt replacement of the desirable quantity of water in the tubes after each pressure drop can be provided for in the design by proportioning the water compartment to hold between the upper and lower levels at which the anti-priming valve closes and opens, the quantity of water required to meet the severest conditions.

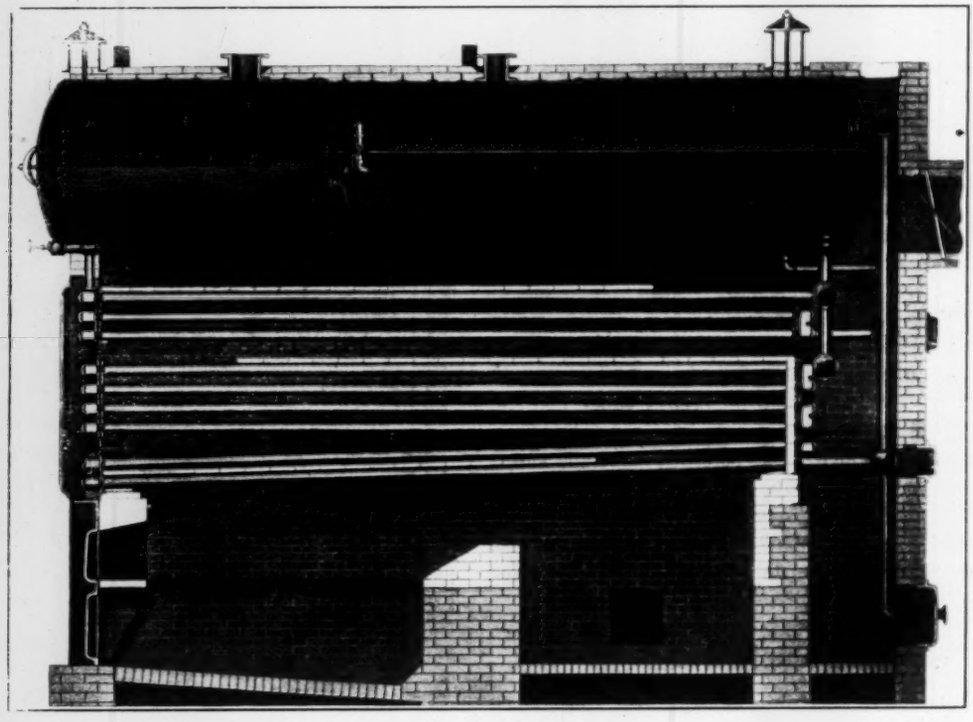


FIG. 2 SINGLE-ENDED DOWNFLOW BOILER, STANDARD DESIGN

Following are some of the new ideas embodied in the latest cross-drum design of downflow boiler.

a The diaphragm is omitted. The front drum serves as the water compartment. The steam drum drains into the water drum through a three-tube connection controlled by the anti-priming valve. One 4-in. tube connection serves as a bypass. The cross drums are more convenient for inlet and upcast connections. The drums are free from unequal strains, and are more accessible.

b The feedwater-heating coiled element is swung so that it can be moved 2 in. sidewise at either end when necessary to remove and replace a junction box, or when access to the handholes, entirely clear of the inlet or upcast tubes, is desired for cleaning or replacing tubes. It is not necessary to move the tubes to insert a tube cutter, expander or cleaner, but it may sometimes add to the convenience.

c The bottom row of tubes go through a crossbar at the rear end which supports the tubes above it. The whole bottom row can be moved 2 in. sidewise to bring the upcasts entirely clear of the junction boxes or handholes when desired. The bar is carried on ¼-in. rollers. It is made in box shape to form an air trap to prevent leakage of hot gases from the combustion chamber into the rear casing. This box has small holes to admit sufficient air to direct any leakage *into* the combustion chamber in place of the reverse direction. This keeps the bar and rear casing cool and prevents gradual deterioration from excessive heat. The movable box joints and openings where the tubes pass through are made fairly tight so that the leakage is small. What does get through aids combustion.

d In the new downflow design, the entire bottom row of tubes operates on the inclined-tube principle. The flow through the two bottom tubes of each element is now parallel in place of serial. These two tubes now discharge directly into one 4-in. upcast like the two staggered bottom tubes of a Babcock & Wilcox section. None of the other tubes above the bottom row discharge into this upcast. The steam is discharged above the water level. It does not have to pass through water and is entirely free to escape into the steam compartment without interference under all conditions of operation.

ANNUAL MEETING DISCUSSIONS

Written Discussions of the Papers Presented at the Thirty-Seventh Annual Meeting of The American Society of Mechanical Engineers, New York, December 5 to 8, 1916

BELOW are the remaining written discussions of the papers presented at the Thirty-Seventh Annual Meeting of The American Society of Mechanical Engineers, held in New York City, December 5 to 8, 1916. One half of these discussions were published in the last issue of The Journal, supplementing the full account of the meeting which appeared in the January issue.

The discussions are printed substantially in full, and will be found to contain a large amount of valuable material supplementing the subject-matter of the papers. Following the discussions are given the authors' closures, which refer also to the oral discussion abstracted in the January number.

WATER FOR STEAM BOILERS—ITS SIGNIFICANCE AND TREATMENT, ARTHUR C. SCOTT AND J. R. BAILEY

M. F. NEWMAN. The authors seem to be unaware of the fact that the most highly efficient water purification is carried on without dependence upon heat. The main factors in boiler-water purification are not heat, soda ash and blowing off, with possible filtration, but accurate softening and purification carried out independently of the variables encountered in the irregular flow of water through the heater and the uncertain degree of precipitation within the heater.

The causes assigned for corrosion include the presence of sodium chloride (evidently the authors have confused magnesium chloride with sodium chloride, since it is a well-known fact that sodium chloride within the boiler is a neutral salt). If sodium chloride were an active corroding substance, then the majority of the boilers in operation in this country would be constantly showing evidence of corrosion.

The authors assign as cause of foaming and priming a concentration of alkali salts, giving secondary place to silt, organic matter, loosened scale, lubricating oil, etc. This belief is commonly held, but it has been found that in the absence of substances in solution which form precipitates upon concentration, water containing alkali salts can be concentrated to a very great degree without any appreciable effect on the steaming quality of the water. The foaming is not due primarily to the alkali salts but to the accumulation of lime, magnesia, iron, etc., that are forced out of solution, thus befouling the water in the boilers with suspended matter, which, by ebullition, is carried to the surface of the water, interfering with the liberation of steam.

The authors' classification of water containing less than 8 grains per U. S. gallon of scale-forming matter as very good, water of from 8 to 15 grains as good, and water with 15 to 20 grains as fair, is altogether fallacious, because no distinction is drawn between temporary hardness and permanent hardness. In any water supply where permanent hardness is present all of the hardening substances become scale-forming substances due to the cementing action of the salts of permanent hardness. Under present-day practice of boiler operation, where the rate of evaporation is carried as high as 300 per cent of rating, any water containing permanent hardness rapidly concentrates to the point where scale formation results, and under such high evaporation any scale formation is quickly followed by tube failure.

The authors' statement that all water softening consists of lime alone, or lime and soda ash, and that no chemicals other than lime and soda ash are ever used under conditions of water softening, is erroneous, there being few water supplies where the precipitation of lime and magnesia can be carried to the proper minimum with these two reagents alone. The adherence to theoretical calculations of the laboratory for requirements of lime and soda ash to precipitate hardening substances is responsible for many failures to obtain from water treatment the results anticipated. There are more factors than the calcium and magnesium salts to be taken into consideration, and each water supply presents a separate problem in itself.

The authors' statement that, after a water-softening plant is in proper working order, the adjustment of chemical feed to raw water, as a rule, will not necessitate any considerable change in the amount of lime and soda ash to be used, can scarcely be reconciled with the facts, when it is known that many of the river-water supplies pass through a seasonal range of from 500 to 700 per cent variation. It is scarcely to be expected that such variations could be met with "a practically constant feed of reagents."

It is quite true that it is not necessary nor desirable to remove all of the calcium from boiler feedwater, but the result obtained in reducing the hardness with different water supplies should and must be brought to a definite standard so that the softened and purified water will contain approximately the same amount of lime and magnesia under all conditions, regardless of the varying quantities of sodium salts or other impurities. The reduction of hardness to entirely eliminate permanent hardness and keep the remaining lime and magnesia compounds within a total of two grains per gallon, is the result obtained in correctly softening a water supply from any source. This degree of softening must be constantly maintained, and on such uniform softness depends the success of water purification for boiler feed.

The statement that large amounts of sodium chloride tend to make water corrosive is erroneous. It is the various substances in solution, notably magnesium chloride, which, under boiler conditions, produce the corrosive effects. Waters containing large amounts of alkali salts, especially sodium carbonate and sodium chloride, have a tendency to foam, not because of the presence of these salts alone, but because with these salts present, much lime or magnesia is precipitated, due to concentration and heat, and the suspended matter thus formed produces a foaming tendency.

The foaming resulting from the use of soda ash is mostly due to forcing calcium and magnesium out of solution, or to the soap-producing effect from grease and oil.

The relative terms *high* and *low* as applied to alkali salts do not determine the suitability of water for softening and purifying for boiler feed, for with the reduction of calcium and magnesium to a minimum and with an elimination of oil and grease, waters containing as high as 200 grains per gallon of sodium salts are frequently used for boiler feed without any difficulty being experienced with foaming and priming, and when using such water the controlling factor is to avoid too

great concentration of the residual calcium and magnesium salts.

The dependence placed upon the empirical soap test for determining hardness, and the reliance on lime and soda ash, or upon heat and soda ash alone, give a false impression of the true procedure required to soften and purify boiler feedwater from any source. Neither heat and soda ash alone, nor lime and soda ash treatment alone, will meet all conditions so generally as to permit of the statement that such procedure includes all of the requisites for purifying boiler feedwater.

F. F. VATER. I would like to ask why the hot process of water softening is classed in the paper with such devices as live-steam purifiers and boiler compounds. The cold process would be more appropriately classified with these than the hot process.

Any chemical reaction will be more thorough and quicker with heat applied than without. This being true, the treatment of water hot offers possibilities of efficiency not attainable in a cold process. Treating water at 200 deg. fahr. will enable one to begin with a water containing 25.59 grains of incrusting matter per gallon and deliver it into boilers with a hardness of 2 grains per gallon with a causticity of from 0.4 to 0.5 of a grain per gallon and an alkalinity of 3½ to 4 grains per gallon, not occasionally, but constantly.

Again, treating water at 200 deg. fahr. will enable one to begin with a water containing 17.97 grains of incrusting matter per gallon and deliver it into boilers having zero hardness as determined by soap solution, causticity 1.8 and alkalinity 6.7 grains per gallon.

A gravimetric analysis of the treated water shows but 85/100 of a grain of incrusting matter per gallon.

I would suggest that the authors compare labor cost of operating a cold process, either intermittent or continuous, with the records made by the hot process, which is $35.00 per month for a plant handling 80,000 gallons of water an hour, operating 24 hours a day. Plants of this size are in continual operation, and there is no reason why one cannot be built to handle any quantity of water.

There are advantages in plant operation obtained by treating water hot other than chemical and labor costs, but space will not permit bringing these out here. Only one plausible criticism of the hot process is in existence, and that is the possibility of heat losses. Hot-process machines can, however, be placed in open air, 10 deg. below zero, and covered, so that the loss in temperature between the heated water and the water as it comes from the machine will not exceed 0.5 deg. fahr.

GEO. H. GIBSON, whose discussion of this paper was publsihed in full last month, appended to this discussion the description of an apparatus by means of which the softening reagents used in hot-process systems are fed with great accuracy and sensitiveness. The description follows:

This flow proportioner is of the type in which the secondary flow, the chemical reagent in this case, is discharged through an orifice under a pressure proportional to the velocity head of the raw water entering the softener. Referring to Fig. 1, *A* is a perforated diaphragm inserted in the raw-water supply pipe. From each side of the diaphragm small pipes lead to the sides of the differential piston in cylinder *B*. The piston rod extends through both ends of the cylinder, to avoid unbalanced areas, and its lower end carries a flat valve disk covering an opening through which chemical solution is pumped constantly by the circulating pump *C*. The differential pressure forces the valve disk against the escaping fluid, and a pressure is therefore maintained upon the latter proportional to the differential head due to the flow of raw water past the orifice at *A*. The bulk of the chemical escapes under the edges of the valve and returns to the chemical tank, but a portion discharges through a small orifice into the open funnel *D*. Due to the proportionality of pressures this flow is at all times proportional to the flow through the raw-water orifice. The chemical-proportioning orifice, not being in contact with the atmosphere, does not accumulate scale or sediment. From the funnel the measured portion of the chemical descends to the chemical feed pump *E*, by which it is lifted to the top of the sedimentation tank, there encountering the heated raw water from the open feedwater heater.

It is found that in actual practice the accuracy of feeding of reagent is within 2 per cent; in fact, a pressure gage communicating with the solution pressure chamber makes a very good flow meter for the raw water, and the total amount of raw water used can also be determined from the amount of chemical removed from the chemical tank.

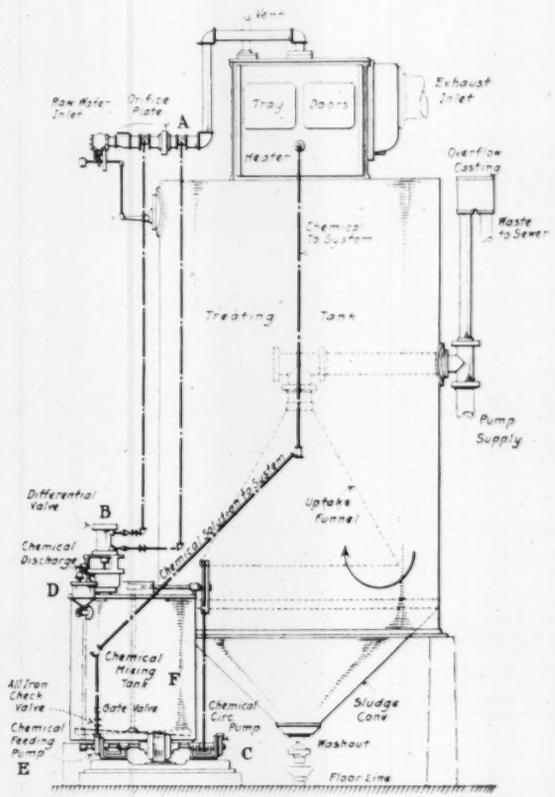


FIG. 1 CHEMICAL-FEEDING APPARATUS FOR USE WITH HOT-PROCESS WATER SOFTENERS

The main supply of the chemical reagent is kept in constant agitation in the tank *F* by paddles driven by the same motor which operates the two pumps. This tank is located on the ground, avoiding the lifting or hoisting of chemicals, and the whole chemical feed apparatus is in the open and readily inspected. The positive feed of the reagent renders the action of the apparatus entirely independent of any back pressure carried in the softener.

The combined softener and feedwater heater, because of its small size, due to the more rapid reaction and sedimentation,

can ordinarily be placed within the boiler room, without requiring special housing or foundations. There is also usually a considerable saving in piping and other installation costs.

CLOSURE BY MR. BAILEY

J. R. BAILEY. Mr. Fowler deplores the skipping over, in the paper, of "the ingredient which occurs in almost all boiler waters—organic matter," but the following extracts from the paper indicate that this criticism is not justified: "Waters low in mineral content but high in organic matter, though perfectly clear, may be troublesome, because a part of the organic matter precipitates. Peaty waters are harmful to boilers by reason of the vegetable acids they contain. The bad effect of mineral or vegetable oils finding their way into the boiler-feed water is well understood."

Mr. Newman takes exception to our belief that "large amounts of sodium chloride also tend to make waters corrosive," overlooking the fact that, where the hypothetical combinations in a water analysis show magnesium chloride, all the sodium is reported as chloride. Under such conditions it would be expected that a heavy concentration of chlorine ions, reported in the main as sodium chloride, would necessarily increase the corrosive action. He further objects to the classification of a water as *good* that contains less than 8 gr. per gal. of scaling salts, because "no distinction is drawn between temporary and permanent hardness;" on the contrary, this distinction is emphasized in the paper with utmost clearness.

Mr. Newman also points out that "the adherence to the theoretical calculations of the laboratory for requirements of lime and soda ash to precipitate the hardening substances is responsible for many failures to obtain from water treatment the results anticipated." My thorough accord with this contention is attested by the statement in the paper that "the best results can be obtained in water softening by controlling with chemical tests the successive batches of water treated." Mr. Newman's statement that there are "few water supplies where the precipitation of lime and magnesia can be carried to the proper minimum with lime and soda ash alone," is challenged by the satisfactory results the process has given in the hands of thousands of operators.

I wish especially to take exception to the comment by Mr. Newman that "the authors' statement that after a water-softening plant is in proper working order the adjustment of chemical feed to raw water, as a rule, will not necessitate any considerable change in the amount of lime and soda ash to be used, can scarcely be reconciled with the facts, when it is known that many of the river waters pass through a seasonal range of from 500 to 700 per cent variation. It is scarcely to be expected that such variations could be met with a practically constant feed of reagents." It is to be observed that we say that *as a rule* no *considerable* change in the chemical feed will be necessary. Why did Mr. Newman not quote this statement in the paper: "It is impossible to regulate automatically the feed of chemicals to compensate fluctuations in the scaling ingredients of water"? If there is any one point that is stressed in the paper, it is that without chemical control the lime-soda-ash process will probably prove unsatisfactory. Mr. Newman asserts that a concentration of alkali salts cannot be assigned as a cause of foaming, but that foaming is brought about by the accumulation of lime, magnesia, iron, etc. The question arises why, if this be the case, certain waters in alkali countries cannot be used in boilers? It is a very common observation in laboratory practice that solutions, after attaining a certain viscosity through concentration of salts of any nature, bump and foam, and such a condition is certainly analogous to that which may arise in a boiler, where the water used is high in alkali content.

Mr. Kent minimizes the waste heat that is due to boiler scale, but I think the coal bills of many steam users will offer mute protest to his contentions.

What Mr. Applebaum says about the Permutit process demands attention, but the fact remains that Permutit softeners have not yet been generally introduced in this section of the United States.

Mr. Vater and Mr. Gibson contribute some very interesting data on the very satisfactory results obtained in the hot-process softeners, of the efficiency of which there is no question. The fact should not be lost sight of that a great many operators of small steam plants cannot afford the investment required for the installation of a patented water softener. Their only hope lies in a home-made water softener, and in using the cold process of treatment with lime and soda ash. All large steam users should install a standard softener with mechanical features that will demand a minimum of supervision and yield maximum efficiency.

THE IMPACT TUBE, SANFORD A. MOSS

VICTOR R. GAGE. Work done on blower testing in the Sibley College laboratories verifies some of the conclusions drawn by Mr. Moss. We have found that the impact tube gave reliable and consistent results, not subject to error from slight misalignment or from stream lines not parallel to the pipe walls. Difficulty has been encountered in obtaining a satisfactory method for determining the pressure head, i.e., the so-called "static pressure" of moving fluids.

It is our custom to use as small an opening as is possible, without rounding the corners, but with all burrs removed, and with the pipe carefully smoothed, for measuring pressure head. Our laboratory experience has led us to this. In one case, using a large hole, the pressure head was of a considerably different value than when the manometer was connected to another and exactly similar hole about nine inches away. By greatly reducing the size of the holes, the values became practically the same. Further investigations indicated the existence of eddies and standing waves. The conclusion was drawn that a large opening was subject to more danger of receiving some (positive or negative) impact from currents of fluid not parallel to the pipe wall, and that the skin-friction effect would protect a small hole to some extent. The smaller the hole the more the protection. This conclusion is tentative. With ordinary or higher velocities the flow is always turbulent, and care must be exercised in obtaining measurements of pressure head, both as to the means used and the place where the instruments are located.

With air at very high velocities (about a mile a minute) it was once found that the pressure head was not constant across an 8-in. pipe, and was actually less than atmospheric pressure although the blower was discharging into atmosphere through the pipe. The discharging steam was convergent after leaving the pipe.

For several years the arrangement shown in Fig. 8 of Mr. Moss' paper has been used in place of a pitot tube, as being more satisfactory, in the regular students' laboratory experiment upon testing of blowers.

In regard to the use of a thermometer, we have used one first bare and then protected, placed in the jet of steam in a throttling calorimeter to illustrate the direction of the changes in the adiabatic conversion of heat into kinetic energy, and

back again to heat. The bare thermometer bulb only partially checks kinetic energy; there is a very perceptible temperature rise upon furnishing a more complete checking of the velocity, although the bare-bulb indication is considerably higher than the temperature corresponding to isentropic expansion.

JOHN L. ALDEN. An impact tube with properly made static-pressure holes in the pipe wall will give as accurate a determination of velocity as the best pitot tube. In addition, the tube itself is much less delicate and is more easily manipulated because of the absence of the tiny static-pressure orifices. However, it is extremely doubtful whether the large static openings in the pipe, as described by Mr. Moss, are not a source of error. Holes ¼ in. to 1 in. in diameter are very likely to be influenced by the velocity, and will probably give a combined reading of static and velocity pressure. If anything, the error is greater by using a large hole and getting velocity influence than by using a small hole and having a slight possibility of leakage. This leakage trouble is one not ordinarily encountered, I think, and it would seem that a lower static reading should be attributed to the measurement of the true pressure with the small hole rather than to leakage. The tests by W. C. Rowse at the University of Wisconsin, recorded in Vol. 35 of the Transactions, show pretty conclusively the effect of large static holes in recording velocities lower than the actual. The same conclusions apply in a considerable degree to static orifices in a pipe wall. The piezometer ring is unreliable, for the reason Mr. Moss has given. It does not correctly average the static pressures around the pipe.

The impact-tube law as stated in the paper is merely a restatement of the law of conservation of energy. In other words, the kinetic energy of the jet may be transformed into potential energy in the impact tube with only the immeasurable loss in the tube itself. Such a conclusion should be expected, as the impact tube is primarily an instrument measuring energy.

Testing a fan by the use of a single impact tube in the discharge pipe, as shown in Fig. 10, does not give a true indication of the output of the fan. Two tubes must be used, or the static vacuum at the inlet must be measured, for otherwise the fan is not credited with the negative pressure which it is producing. This suction is used in creating flow through the inlet. Part of it is shown in the form of velocity and the rest is lost in overcoming the resistance of the inlet. Where the inlet and outlet areas are equal, the pressure not credited to the fan is the entry loss referred to. The method shown in Fig. 11 is the correct one for fans and blowers as well as centrifugal pumps.

The writer believes that the orifices shown in Fig. 18 would give very doubtful results if the velocity of approach were appreciable. From the standpoint of smooth stream flow these nozzles are very bad. At high entrance velocities, 3000 feet per minute or greater, the contraction of the jet at the throat would probably be great enough to prevent filling of the mouth of the orifice. In other words, the condition of Fig. 12 would be greatly increased, and the expansion of the jet to the size of the orifice would not take place until the end of the orifice was passed. If this condition actually occurred, the area of the orifice could not be used in calculating the volume. Unless each orifice were calibrated for all high velocities, it would seem unsafe to use this form. If the approach were more gradual and the fillets were large to smooth out the stream lines, an orifice might be made which would cause no contraction whatever.

CLOSURE BY MR. MOSS

SANFORD A. MOSS. Mr. Alden refers to Mr. Rowse's paper in Vol. 35, Trans.Am.Soc.M.E., as showing that large static holes give error in static pressure. In all cases the errors reported by Mr. Rowse in measurement of static pressure were in the static pressure in a pitot tube. The reason they were in error is due to the fact that the flow was not parallel to the surface. Mr. Gage also notes error due to large static holes when there were eddies. I believe, that with proper length of straight pipe, or other arrangement for insuring that flow along the surface is parallel to it, the size of the static hole is unimportant. However, there is no objection to a small hole if any one prefers it and has tight piping.

Mr. Alden has some fears regarding the shape of the orifices illustrated, but actual experience with these orifices for many years shows that Mr. Alden's fears are groundless and that the mouth is filled in all cases, even for extremely high velocities. The essential point of an orifice is a large fillet or gradual curve just preceding a parallel portion. A long gradual approach is not necessary. In steam-turbine nozzles, where very high velocities are used, this has also been found to be the case.

The errors in the theoretical adiabatic perfect-gas formula to which Mr. Buckingham alludes are negligible for all engineering work. The validity of the use of the theoretical formulae has been justified by a great deal of experimental work.

In The Journal and pamphlet editions of the paper, owing to an error, the term *down stream* was used instead of *up stream* in a number of cases.

THE PROPORTIONING OF SURFACE CONDENSERS, GEORGE A. ORROK

WILLIAM D. ENNIS. In their present forms, Mr. Orrok's several papers would all of them need to be consulted to obtain a definite program for procedure in condenser design. The following is offered as a summary and amplification of his method.

Let W = maximum weight of steam to be condensed, lb. per hr.
t_s = temperature of steam
Q = weight of condensing water, lb. per hr.
t_0 = inlet temperature of condensing water
t_1 = outlet temperature of condensing water
S = aggregate external surface of condenser tubes, sq. ft.
U = coefficient of transmission
t_m = mean temperature difference
L = latent heat of vaporization of steam at temperature, t_s
x = dryness of the steam at temperature t_s.

Then

$$WxL = Q\ (t_1 - t_0) = SUt_m \quad \ldots\ldots\ldots\ldots [1]$$

The following rules will fix values to be taken in the above:

If H' denotes the B.t.u. in 1 lb. of steam at throttle conditions, h_s the heat of liquid corresponding with the temperature t_s, and B the steam rate of the engine, lb. per i.hp-hr., then

$$xL = H' - h_s - \frac{2545}{B} \quad \ldots\ldots\ldots\ldots [2]$$

This rule is on the safe side, since it assumes all heat not converted into work to be still present in the exhaust.

For t_1 use a value 5 deg. to 10 deg. below that of t_s.

The steam temperature t_s is that corresponding with the absolute steam pressure p_s at the exhaust nozzle. If v denotes the vacuum at the condenser, in. of mercury, and v_n the loss of vacuum between condenser and exhaust nozzle (also in. of mercury), then, ignoring the influence of any air present,

$$p_s = 14.696 - 0.493\ (v - v_n) \quad \ldots\ldots [3]$$

For good design, Orrok uses $v_n = 0.2$.

The value of U that is now recommended by Mr. Orrok is $325\ V^{0.6}/t_m^{0.4}$, where V = water velocity in tubes, ft. per sec., which water velocity varies from 7 to 10. In usual practice, this is equivalent to a value of U around 800, or about four times the value once employed. The expression given for U is sufficiently applicable for any standard material in a new tube. (Foul tubes may decrease U 50 per cent.) The effect of the steam-richness ratio is now thought to be represented by $(p_s/p_t)^2$ rather than by $(p_s/p_t)^3$ as in Vol. 32, Page 1162. With tight condensers and good vacuum pumps, (p_s/p_t) may be expected, according to Mr. Orrok, to lie between 0.95 and 0.97. The constant in the expression for the value of U has been made to contemplate such values. Safe values of U for commercial design are further considered below.

The mean temperature difference, assuming that the exponential law holds (see Trans. Am.Soc.M.E., Vol. 32, Page 1211), is

$$t_m = \left[\frac{\frac{1}{8}\ (t_1 - t_0)}{(t_s - t_0)^{1/8} - (t_s - t_1)^{1/8}}\right]^{8/7} \quad \ldots\ldots [4]$$

The arithmetical mean is $t_a = \frac{t_1 + t_0}{2}$. The logarithmic mean is

$$\frac{t_1 - t_0}{\log_e \frac{t_s - t_0}{t_s - t_1}} \quad \ldots\ldots [4a]$$

(See Trans. Am.Soc.M.E., Vol. 32, Page 1211.) This gives a value close to t_m.

The expanded equation for design is then

$$Q\ (t_1 - t_0) = \frac{325\ V^{0.6} S}{t_m^{1/8}} \cdot t_m = 325\ V^{0.6} S\ t_m^{7/8}$$

$$\text{or, } S = \frac{Q}{40.63\ V^{0.6}} \left\{ \frac{1}{(t_s - t_0)^{1/8} - (t_s - t_1)^{1/8}} \right\}^{8} \quad \ldots\ldots [5]$$

Let d = outside diameter of tubes, in.
t = thickness of tubes, in.
n = number of tubes in each pass of condenser
l = aggregate length of passes, ft.

Then area per tube for passage of water $= \frac{0.7854\ (d - 2t)^2}{144}$ $= 0.00547\ (d - 2t)^2$ sq. ft. Water velocity = cu. ft. per sec. ÷ aggregate area per pass

$$= V = \frac{Q}{62 \times 3600 \times 0.00547\ n\ (d - 2t)^2} = \frac{Q}{1220\ n\ (d - 2t)^2},$$

$$\text{or, } n = \frac{Q}{1220\ V\ (d - 2t)^2} \quad \ldots\ldots [6]$$

$$\text{Also, } S = \frac{\pi d}{12}\ nl, \text{ whence } l = \frac{3.83\ S}{dn} \quad \ldots\ldots [7]$$

As an example, assume a unit of 2000 maximum i.hp. at 226 lb. throttle pressure and 27.68 in. vacuum, using 12.725 lb. of dry steam per i.hp-hr. Take the inlet water at 70 deg., outlet water at 95 deg. and water velocity at 8 ft. per sec.

By Equation [3], $p_s = 14.696 - 0.493\ (27.68 + 0.2) = 1.0$, whence t_s (from the steam table) is 102 deg. Then by Equation [4] the mean temperature difference is

$$t_m = \left(\frac{\frac{1}{8} \times 25}{32^{1/8} - 7^{1/8}}\right)^{8/7} = 16.64 \text{ deg.}$$

(Note that the arithmetical mean is 19.5 deg. and—by Equation [4a]—the logarithmic mean is 16.5 deg.)

At 226 lb. throttle pressure, $H' = 1200$. Since $h_s = 70$, Equation [2] gives

$$x\ L = 1200 - 70 - \frac{2545}{12.725} = 930 \text{ B.t.u.}$$

Then by Equation [1], $W x L = 12.725 \times 2000 \times 930 = 23{,}668{,}500$ B.t.u. per hr. Setting this equal to $Q\ (t_1 - t_0)$, the weight of circulating water per hour is

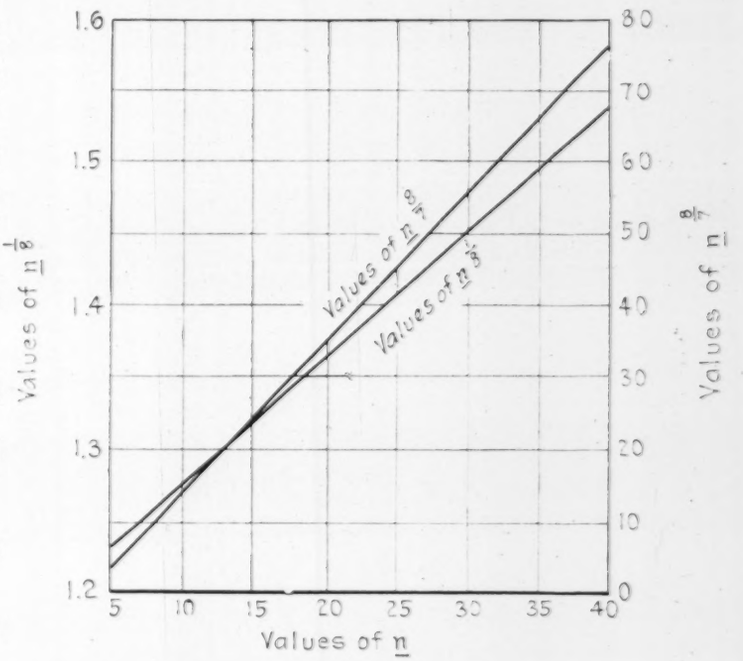


FIG. 2 GRAPH FOR EVALUATION OF EQUATIONS [4] AND [5]

$$Q = \frac{23{,}668{,}500}{95 - 70} = 946{,}740 \text{ lb.}$$

Equation [5] now gives the surface directly:

$$S = \frac{946{,}740}{40.63 \times 8^{0.6}} \left\{ (102 - 70)^{1/8} - (102 - 95)^{1/8} \right\}^{8}$$

$$= \frac{946{,}740 \times 0.2669}{40.63 \times 3.485} = 1780 \text{ sq. ft.}$$

If 1-in. No. 18 B.W.G. tubes are used, Equation [6] gives

$$n \quad \frac{946{,}740}{1220 \times 8\ (0.902)^2} = 119$$

as the number of tubes per pass. From Equation [7]

$$l = \frac{3.83 \times 1780}{1 \times 119} = 57.3 \text{ ft.}$$

This is the aggregate length of all passes. In the absence of certainty as to values of U and t_m, no effort is here made to choose a *best* ratio of l to d. Usual ratios are between 30 and 50, indicating that two passes will be desirable in this condenser.

(The value of U for these conditions works out $325 \times 8^{0.6} \div 16.64^{1/8} = 796$.)

It is perhaps unreasonable to expect that definite and generally satisfactory values of U will ever be established. The transmission will inevitably decrease in service, the air-richness influence is doubtful and the question of steam circulation has not been (perhaps cannot be) included. The rate of heat transmission in a surface condenser is a variable quantity, like the rate of transfer in a steam boiler. For safe design to meet anticipated operating conditions U should probably be taken at about 400, with due allowance for factors known to influence its value. Perhaps Weir's relation, $U = 250\ V^{0.6}$, may be found safe if divided by a *hedging* factor of 2.

The mean temperature difference, which is only a slight factor in the determination of U, is itself a nearly linear factor in the total transfer. Accurate knowledge of its value is therefore of first importance. The weight of evidence points toward an exponential law for the rise of water temperature in the tube, but the logarithmic mean given by Equation [4*a*] represents very closely the result of such law for any ordinary conditions. Moreover, in Equation [4], exact values of the exponents are not fully settled.

A quick method for evaluation of Equations [4] and [5] is afforded by Fig. 2.

CLOSURE BY MR. ORROK

GEORGE A. ORROK. I am greatly pleased with the form which the discussion of the paper has taken. Professor Ennis has amplified the suggested method given in the paper by introducing factors which are usually slurred over. In the actual tests N was always known by the weight of circulating water times its temperature rise, and the steam was rarely wet, as it nearly always is in an actual condenser.

Mr. Stuart's discussion emphasizes some points which perhaps have not been brought out in sufficient detail. Mr. Kothny referred to my paper on Air in Surface Condensation (Trans.Am.Soc.M.E., vol. 34, p. 713) for data on air leakage, and I wish to reiterate again my statement that eternal vigilance is the price of freedom from air leakage. From 1 to 3 cu. ft. of free air per min, is very good practice with any commercial condenser, and this result can be obtained with condensers of the largest sizes.

Mr. Gibson mistakes K for U, and U is the coefficient of heat transmission in the fundamental formula $N = SU\theta$, while K is the reduced coefficient as given in Par. 10 $\left(K = \frac{U\theta^{1/8}}{V_w^{0.6}}\right)$ with a further reduction for air richness.

A reference to Trans. Am.Soc.M.E., vol. 32, p. 1210, where the "three-dimensional" diagrams are shown, should make this distinction clear as well as Professor Ennis' question about the exponent (7/8).

Mr. McBride brought up the very interesting point that frequently it is necessary to assume primarily the tube length and diameter in some commercial designs. I have met this case in my own practice a number of times, but have always solved it by trial and error instead of using the arithmetical mean.

Mr. Bancel has again brought up the question of the depth of the tube bank, and incidentally the velocity of the steam among the tubes. This is a very complicated subject, being mixed up with the prevalence of the water film on the steam side of the tubes. There has been some little mathematical work along these lines, but in our experiments the results were negative, as was also the case with the observed results on commercial condensers. At the present time, however, there seems to be no reason to doubt the statements regarding this subject in Trans.Am.Soc.M.E., vol. 32, p. 1160. Since writing the paper John E. Bell has read a paper on this subject before the Engineers' Society of Western Pennsylvania, in which he shows that a definite relation exists between the transfer rate and the cube root of the water condensed per hour per square foot divided by a function of the film temperature. More work is being done along these lines, but all I can say at present is that it is probable that we may be able to show a physical basis for the exponential formula of temperature rise.

A PROPOSED PLAN FOR THE ACTIVITIES OF THE MACHINE SHOP PRACTICE SUB-COMMITTEE OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, H. K. HATHAWAY

L. C. BROOKS. While heartily indorsing Mr. Hathaway's attitude, I would point out that the electrical problem received no mention except in the fourth paragraph, where Mr. Hathaway advised a certain condition where the motor was overloaded. The policy of electric drive is becoming more and more prominent and is considered as a part of the installation. With proper investigation the following subjects would give valuable information to the public: The question of belt vs. electric drive, the advantages and limitations of individual drive or group drive, the horsepower required to drive, the relative advantages of individual drive for special machines, as planers, car-wheel lathes, etc.; in connection with electric drive, drum-type manual control vs. automatic control, dynamic brake as applied to electric control for certain machines, safety-first protection to the operator. In connection with Mr. Hathaway's tentative classification provision should be made for the question of operation, which is of vital importance.

CLOSURE BY MR. HATHAWAY

H. K. HATHAWAY. It is very gratifying that my suggested plan should have aroused so much interest, and that it should have been received so favorably. The Sub-Committee on Machine Shop Practice should, I believe, give careful thought to the utilization of existing committees, and in fact should take into account any existing agencies, either within or without the Society.

Mr. Pigott is right in pointing out that to accomplish results the committee must be handled more like an operating company than a council of advisers. To make this practical necessitates, as stated in my paper, a secretary who can devote his entire time and attention to the affairs of the committee, seeing that the program is carried out.

While it is desirable that ultimately the codified data on machine-shop practice should cover not only current practice but its development, it would, as Mr. Eberhardt suggests, be wise not to spend too much time in the beginning on the collection of data from papers and articles that have been published in the past, but to give particular attention to new material as it appears.

I regret that there should have been so much discussion as to the form of classification adopted, as while it is no doubt important that the best method of classifying be used, it is not nearly so important as that some form of classification be adopted, and it is still more important that some action be taken toward the carrying out of a definite plan leading to the further development of machine-shop practice as a science.

RELATION BETWEEN PERPETUAL-INVENTORY VALUE AND APPRAISAL VALUE, CHARLES PIEZ

HARRY BARKER.[1] The fundamental term "depreciation" has become so involved in a maze of differing definitions that even when engineers endeavor to use it quite technically it conveys different ideas to different persons. If we could agree on an acceptable vocabulary which we would employ in our discussions, a great gain would be made. Fallacies would be more quickly exposed and truths better comprehended.

I first endeavored about a year ago (in the proceedings of the Philadelphia Valuation Conference, held under the auspices of the Utilities Bureau) to harmonize some of these differences, and I desire here to draw attention to much the same ideas as then advanced.

The meanings which have been given to the term "depreciation" are seen to fall into two general classes: (*a*) losses in value of physical property, and (*b*) sums secured from earnings to offset loss in value of property.

The first group of definitions of "depreciation" can be further divided into: (1) aggregate actual or estimated loss in value from all causes; (2) the loss in value due to wear-and age-deterioration as distinguished from the loss of value from liability of obsoletion or inadequacy; and (3) the loss in value due to loss of ability to render full service or to decreased efficiency.

The second group is seen to be split into: (4) an annual accounting figure representing the depreciation for the year, or any other given period, deducted from gross earnings in computing probable true net earnings; (5) an annual sum used in making up the amount of necessary income to be secured by the rates. (This last is often an annual amount to be set aside out of the earnings to help create a reserve which will equal the cost of the several items of plant when they are retired from service and will pay for the renewals to the extent of the cost of the items retired. It might well be a direct repayment out of earnings of investment, equal to the annual loss in value of property due to depreciation.)

There is finally a sixth definition of depreciation as: Various aggregates of the annual sums secured from time to time to compensate for loss in value through deterioration or obsolescence, or both.

The several shades of meaning indicated in these definitions are sufficiently different to make our discussions run on diverging tracks. They show the need of greatly restricting our use of the word "depreciation." Our language is not so lean that we have to use one word in so many senses. Therefore I have a few propositions to advance.

The first definition—as the aggregate loss in value from wear-deterioration, inadequacy, supersession, antiquation, dilapidation, etc.—is probably the most used and the original one. This can well be adhered to, and a few available terms employed to carry the other meanings given.

The idea involved in the second definition makes a most useful distinction, which should be preserved, but it is more definitely indicated by "wear-deterioration," "age-deterioration" or "wear-and-age deterioration," according to the precise shade of meaning needed.

The third definition—loss in value due to diminished power to function or to decreased efficiency—has no real place in depreciation discussions, for mere ability to render the original service does not indicate lack of depreciation, and percentage of service ability (which is not the "serviceability" of the dictionary) alone does not measure value. (It indicates relative value only when the duration of that percentage of service ability is considered; if one machine can yield certain service for 10 years and a second machine can yield the same service for 20 years, their real values are not equal.) Instead of speaking of this loss of service ability as depreciation, it should be called "service-ability drop," or some equivalent.

The fourth definition has sprung up to give a short expression equivalent to "deductions for depreciation expense," or something like that. If there were not so many definitions in the field needing weeding out, its abbreviation to "depreciation" would be excusable. But, because of the confusion induced, the longer phrase should be reverted to.

Similarly in the case of the fifth definition, it is advisable to say "allowance for depreciation expense," or, more briefly, "depreciation allowance," and not merely "depreciation." Between speed of speech and accuracy of expression there should be no question of choice. Depreciation allowances correspond to what some engineers call a "theoretical depreciation" in contrast with what they designate as "actual depreciation" (meaning wear-deterioration) found by examination.

Definition five conveniently reduces to "renewal allowance," and for further simplicity to the coined word "renewance," which the speaker has found generally understandable. The first and the fifth definitions are perhaps the ones most used, so that it is a great advance to agree to speak of "depreciation" as the actual lost value, and "renewance" as one year's part of the compensation therefor.

However, it is little more than a convenient fiction to speak of building up reserves for renewals, since those funds have no relation to the amounts spent for the new equipments. Electric railways have been known to scrap generating stations and purchase power from central-station companies. In general, replacements are made with radically different equipment. What the business must be made to yield, in line with the Supreme Court's dictum, is full compensation to the utility concern for the loss in value of property from all the various causes already outlined. That is to say, the rates must cover the liability for retiring plant rather than the cost of renewing it.

"Retirance," therefore, has been substituted for "renewance." Retirance, then, is the annual amount to be repaid the corporation to compensate it for each year's depreciation. Retirance is a definite factor in rates, and in its nature is a repayment of invested capital. Unit retirance may be spoken of as a subdivision of retirance, as it has been apportioned over rates. Wear-retirance, age-retirance, obsoletion-retirance, etc., become useful special terms which can be accurately employed. The place of aggregate retirance is obvious.

By such a restriction as outlined on the employment of the terms "depreciation," "wear-deterioration," "depreciation-allowance," "retirance," etc., discussion is not appreciably encumbered and a fundamental cause of exasperating confusion is removed[2].

ROBERT J. HEARNE. The entire subject of physical valuation is bound up with proper cost-keeping and a perpetual inventory, and the greatest of these is the last. Properly kept, a perpetual inventory is a time saver and a daily corrector

[1] Associate Editor, Engineering News, 10th Ave. and 36th St., New York.

[2] Since this discussion was presented, the Valuation Committee of the American Society of Civil Engineers has made its final report; and in this the further useful distinction is drawn between "decretion" (reduction of service life), the cause, and depreciation (reduction of money value), the effect. Attention also should be here directed to the recent report of the Valuation Committee of the American Electric Railway Association in which a standardized list of 21 valuation terms, comprehensively defined, are recommended for use in place of the 300 odd terms now largely employed. (These terms were reprinted in Engineering News, Oct. 26, 1916.)—H. B.

of values and costs, and keeps everything up to date. It takes some trouble to install and some thought to keep going, but it pays.

I have had experience for nearly 15 years with a method that is adapted to almost any business. The business to which the method has been applied was established over 25 years ago, and includes importing, manufacturing small machinery, and dealing in supplies, so that the problems were numerous. To apply this method to a new business is very easy, and it can be applied to an old business a little at a time.

The inventory begins with the receipt of goods, either through purchase or manufacture, and a written invoice from the factory should be treated just as an invoice for purchases. Sales are deducted from inventory, of course, and so should be all tools and equipment which are worn out and junked. A written invoice for all goods junked is vital.

The proper classification of every article must be decided on in advance, and this should be done, as far as possible, in such a manner that each article will fall *naturally* into its class.

There are several grand divisions or classifications, namely:

(*a*) Furniture, Fixtures and Machinery. (Subject to deterioration.)

(*b*) Work in Process. (A proper shop-cost record is required to take care of this.)

(*c*) Merchandise, Supplies and Raw Material. (Generally figured at cost.)

Each grand division can be subdivided as often as experience shows it to be desirable.

In practice it has been found best to number each section. Symbols should be avoided. At first they seem helpful; in the end they are a nuisance. A numerical index is also essential, and it is easily kept. A number once used should never be used for another thing. Numerical and alphabetical indexing answer all purposes.

Physical control of stock is essential. Nothing should be received or given out without a voucher. If one is allowed to help himself to stock, without control, it is useless to attempt to keep a perpetual inventory.

The inventory items should all be on cards. Books are not practical, and a loose leaf is practically the same as a card, and not so serviceable.

A perpetual inventory is very helpful because it shows how goods move, and at what dates they sell, and will generally be more accurate than an actual counting of the goods. Nevertheless, a constant check is kept on the inventory by the simple method of actually counting stock on hand and reporting in writing on a "Goods Wanted Memorandum" before replacing any stock that is low. Any error in the inventory is thus discovered. In practice we have found that the inventory is the more reliable.

Keeping track of merchandise presents no serious difficulties, although most people still rely on the annual inventory. While it is true that Machinery, Fixtures and Tools must be appraised, yet an accurate description, accurate count, and accurate cost must be furnished before an appraisal can be made that is anything more than a guess.

Proper classification is very essential here. It is very wrong to attempt to value line shafting, belts and pulleys as a whole. Every pulley and belt belongs to some machine or to a line shaft, and should be so described in detail, not by guesswork. A separate inventory card should be kept for each line of shaft. The pulleys for driving machines, either directly or through countershafts, and the belts, are part of the driving equipment of each machine. This method simplifies the shafting, pulley and belting problem, as each belt pulley should be accurately described and priced on the inventory card for the machine it belongs to.

In classifying Machine Tool Equipment, only such equipment should be included with each machine as can be used only on that particular machine. For instance, if a number of screw machines exactly alike are used, then the spring chucks should be classified separately, and not as part of the equipment of any one machine. For the same reason milling cutters are not part of the equipment of any one machine.

Drills, taps, reamers and similar tools should always be separately classified. The more subdividing there is done, the easier it is.

Each machine tool should be listed in detail on a separate card, with a list of its equipment as originally bought, with dates and costs. New equipment can be added as bought or made. A proper addition is for freight, cartage and cost of installing, and of the pulleys and belts.

If costs are kept, say, on the right-hand side of the card, they can be totaled up, and the entire original cost shown at a glance. Estimates of present value can be written down, say, annually on the left side of the card in a column headed "Present Value," and dated.

Appraisal of present value can only be made by a competent, honest person who knows all the facts and is familiar with the business. Appraisals by outsiders are of little value. Taking off a fixed percentage per annum is unreliable. A simple test is to ask for how much cash would you be willing to part with the machine. Honestly applied, this test will give an accurate value. If we cannot assume intelligence and honesty, any appraisal is valueless.

In valuing small tools, such as reamers, taps, cutters, etc., no hard and fast rule can be laid down, but a few general principles will apply. In general, a stock of reamers and cutters in a shop will all be in use, hence all will be depreciated, but as worn-out tools are replaced it is a fair assumption that all are serviceable. A flat depreciation of, say, one-third would probably cover. With taps, drills and files, however, there would always be a large percentage, possibly one-third, which were unused, therefore a depreciation of, say, one-fourth would perhaps be correct. Equipment such as tote boxes and case-hardening boxes is subject to very great deterioration, and probably a depreciation of one-half would be right.

As to count of such items, it should not be guessed at. The rule should be that no tool should be junked until it is reported in writing to the office. The actual throwing out of junked tools should be done periodically, not daily, and no new equipment should be bought or made until an accurate count of that item is reported in writing to the office, for the purpose of checking off inventory.

For instance, if some number-size drills are wanted to replace stock, it is a simple matter to send a memorandum of tools on hand to the office. Inventory is then checked off. A new lot is ordered, and when they are received they are added to the corrected inventory. The worn-out tools are not generally charged to expense. This is taken care of by charging the replacement to expense. If no replacement is made, then the junked tools are charged to expense.

It is easy enough to keep track of the cost of a drawing, but the constant changes are difficult to analyze. It would be very wrong to keep all drawings and divide up the total cost among them. It is impossible to appraise their value. The best method is to keep them constantly weeded out. The inventory can be arranged numerically, using the same number for the drawing as for the part or machine. The same number

should also be used for patterns and special tools and jigs. Our practice is to keep track of original cost of drawing, and add 100 per cent. All drawings on inventory are priced. Drawings in actual use are carried at full price on inventory. Drawings which are not much used are carried at no value; if revived, the full value is restored; if obsolete, they are destroyed.

Patterns are kept track of numerically, a separate card for each. Patterns in general use are carried at full price. Those little used at no value. Obsolete patterns are destroyed. The pattern card is also made to serve as a record of cost of castings, and it is also noted if the pattern is in storage or at the foundry. In figuring the cost of patterns it is proper to figure all cost of making the first patterns. For instance, if a metal pattern is wanted, the first cost of the wooden pattern is figured in the cost of the final metal pattern, even though the wooden pattern is no longer of any use after the metal pattern is made. Alterations in patterns to get good castings are also considered a proper part of cost, but alterations in design are not.

Work in process is controlled by the fact that work is always started in lots or jobs, and time, material and overhead take care of this. Every piece of shop or repair work should be on a separate job ticket, unless very trivial. In this way all changes in equipment are kept track of.

Pipe, fittings and wiring in buildings can be classified and separated into mains and branches, just as suggested for shafting, belting and pulleys. Dead lines should be so marked and valued at practically nothing, but as dead lines are sometimes revived, it is well to keep track of them, unless they are actually abandoned.

In conclusion, it is important to have means of getting rid of all records, drawings, tools, etc. For this purpose a slip is used in which all possible places where there is a record are named, and all obsolete records are thus systematically destroyed. This includes patterns, jigs, drawings, catalogues, etc. If anything is discarded, but there is a possibility of revival, all records, tools, jigs, etc., are put in one box, and marked, for instance, "No. 1364—Section 13—obsolete," and stored away. In time actual junking will occur.

CLOSURE BY MR. PIEZ

CHARLES PIEZ. No schedule of depreciation, no matter how carefully and intelligently framed, will cover all possible conditions and provide for all possible contingencies. A fixed schedule is always lacking in that elasticity which would render it universally applicable, and must on that account be supplemented in unusual cases by exceptional treatment born of intelligent analysis and experience.

In discussing allowances to be made out of profits to cover loss or shrinkage of value, it is well to bear in mind that relatively few manufacturers regularly make such allowances for depreciation, and that even these few have never adopted, or even discussed any standard set of rates.

That loss of value from any one or all of the causes enumerated by Mr. Barker does occur is universally acknowledged. Academic definition of the generally used term depreciation does not stay its inroads on profits nor make the method of providing for these inroads any clearer. Why add such new terms as "retirance" and "renewance" to an already overburdened industrial vocabulary?

What is needed is a presentation of records and experiences, so that out of these we may develop a schedule of rates which can be looked upon as a standard for determining annual allowances against loss of value due to wear-and-age deterioration and obsolescence.

The loss of value is legitimately a part of the cost of the output, a fact which is at present overlooked in many business enterprises; and to correct this omission or oversight, it is to my mind much more effective to start with a sane schedule of rates of depreciation than to start with a definition. I realize, of course, that Mr. Barker's discussion pertains more particularly to the valuation of public-utility properties, where the allowances to be made on individual units may be so large as to justify division into several classes or causes; but in the mechanical industries the terms "annual depreciation" and "total depreciation" contracted from "annual depreciation allowance" and "total depreciation allowance," are so widely understood as to require no further definition.

What is needed is to have some association of the importance and prestige of this Society investigate this subject and recommend a schedule of rates of annual depreciation for adoption.

With the administration proposing a further tax of five per cent on all profits in excess of eight per cent on the investment, isn't it necessary that the engineering societies shall define what so important a factor in the expense of production as depreciation amounts to annually and how provision for it shall be made out of profits?

Mr. Hearne has outlined very clearly a system by means of which a perpetual inventory of work in process, as well as of the other assets of a manufacturing plant, can be introduced and maintained.

I am a strong advocate of the value of running or perpetual inventories for work in process and materials in stores, as well as for buildings and equipment, and Mr. Hearne's discussion is valued because it outlines the possibilities in these directions. In the valuation of small tools I believe it safer and nearer to the truth to assume that this equipment averages about halfway between new and worn out, and to charge off a flat depreciation of 50 per cent instead of a third. I believe his method of valuing active patterns at full cost is dangerous, and the same must be said of his practice in respect to drawings.

I have never heard of purchasing drawings at anything more than a merely nominal sum upon the liquidation of an industry, and patterns in the average industry are subject to such marked deterioration in value through obsolescence as to justify the flat rates of depreciation named in the schedule.

MECHANICAL DESIGN OF ELECTRIC LOCOMOTIVES. A. F. BATCHELDER

GEORGE GIBBS. I take it that Mr. Batchelder's paper is not intended to be more than a very general statement of certain features which must be taken into account in the design of an electric locomotive, together with certain conclusions which he is led to make from his study of the problem. It may therefore be in order for me to give briefly some opinions of my own, and in so doing I am sorry if I must disagree with the conclusions in some respects.

A complete presentation of the subject of electric-locomotive design has yet to be made; all we can do at present is to chronicle experience with various types and classes in different services. Unfortunately the total number actually in service is quite limited and the period over which our experience runs is also in many cases short.

In the first electric locomotives built not so many years ago the chief consideration was to get a machine which would run and pull a train without continually breaking down through some electrical defect; this is the first step in a young art.

When these conditions were satisfied, it then became a question of obtaining the best design from the standpoints of safety, efficiency and low maintenance cost. This second stage is still under way and the end is by no means yet attained, nor can this be expected any more than has been the case with the steam locomotive, in which there has been a tremendous improvement during the last ten years in increased capacity and efficiency.

Many years' experience in testing work for railroads has brought me into very close touch not only with the design of locomotives but of track. I early became impressed with the importance of high center of gravity in steam locomotives and with the importance of reducing the dead weight below springs to the lowest consistent amount. The track structure does not present a perfect and unyielding plane surface; it has defects, both in alignment and surface, and it is elastic. Its elasticity is a saving characteristic as regards safety and the low maintenance cost of track and equipment. Therefore, a locomotive in running over the track has set up in it oscillations and movements, the effects of which become important not only to the locomotive structure but to track, as regards safety and cost of maintenance.

These conditions are well understood in steam-locomotive practice but, unless we are careful, are likely to be lost sight of in designing electric locomotives, where the radical difference in the application of the motive power suggests or permits a variety of wheel arrangements, weight distribution, etc. I cannot here go into a full discussion of this important point, but I can say generally that the elimination of reciprocating parts from the locomotive, a result accomplished in electric locomotives but impossible with steam, does not warrant us in abandoning some of the very important principles well demonstrated in steam practice, namely, that for safe and successful operation under average track conditions, high center of gravity, least dead weight below spring supports and an unsymmetrical wheel and weight distribution give best results. The above applies especially to high-speed operation; for low speeds similar arrangements are also desirable but not so essential.

A word more about the height of center of gravity. There seems to be a tendency to consider that the center of gravity of the machine as a whole is the only consideration of importance, and some electrical designers have been content to secure a fairly high center of gravity by the combination of heavy apparatus in the cab of the locomotive (this being above the springs), with heavy weights carried on the axles or below the tops of the wheels. This arrangement does not give the equivalent of a given height of center of gravity in a steam locomotive (where the bulk of the weight is above springs), as regards the effect on track. A steam locomotive has dead weight only of the driving wheels, axles and boxes; all other weights are spring-borne and thus are not only eased from vertical shock on the track but by the rolling of the mass on the springs tend to effectively relieve lateral rail pressures and convert them into vertical, a condition which conduces greatly to safety and reduction in maintenance both of locomotives and track structure.

The writer, a number of years ago, in taking up the design of electric locomotives for the Pennsylvania Terminal in New York, suggested a method of making an extensive series of experiments to determine the riding qualities of different types of locomotives. The procedure took the form of tests on an experimental stretch of track which was made movable transversely by having the rails mounted on rollers and the transverse motion restrained by stops consisting of hardened-steel points or balls set up against steel strips which, by indentation, register the tendency to displace the track laterally. It was intended by this means to measure the tendency of certain wheel arrangements in locomotives to set up rhythmic side motion and also to register the throw sidewise by defects in track surface. As the result of these tests we obtained much valuable information regarding design of electric locomotives confirmatory of the general principles I have mentioned above, showing the value of an unsymmetrical wheel base for an electric locomotive with a high spring-borne center of gravity and low dead-weight component. I believe a more extensive series of these tests, and an acquaintance with the results by electric-locomotive designers, would accomplish a valuable purpose in clearing up many existing differences of opinion.

Mr. Batchelder speaks of wheel arrangement and height of center of gravity as affecting locomotive design; I am unable to follow his reasoning and, if I understand him, I do not agree with his conclusions. He appears to be trying to make out the case that high center of gravity is unnecessary if you have leading trucks for the locomotive, and that the presence of leading trucks makes it immaterial where the motors are mounted; with these conclusions I disagree. Furthermore, he appears to conclude that a leading truck is essential for high-speed operation by stating that steam locomotives cannot be safely operated backward at high speed. It is common in steam practice abroad, and not unusual in suburban practice in this country, to run steam locomotives backward without leading trucks, i.e., the American type of locomotive. In such service steam locomotives are frequently run at quite high speeds on roads having much curvature. Abroad, especially in England, it is not unusual practice to so operate them over long distances at high speeds. The real objections to the operation of steam locomotives backward are, in the first place, that the view of the enginemen is not good, secondly, that the tender is a short-wheel-base structure having a variable and shifting load, and thirdly, that coal dust which is thrown about becomes very disagreeable to the enginemen. However, I believe that leading trucks are useful in locomotive practice, and favor them, but I simply mention the above to indicate that they are not a necessity for safety.

Mr. Batchelder appears to conclude that simplicity, adaptability, reliability and efficiency require that electric locomotives must be standardized in design in the direction of placing the motive power on the trucks, either geared or gearless motors, and would obtain the requisite power by coupling trucks with short wheel base together, also that this type of locomotive can be used in either high- or low-speed service by simply changing the gear ratio. This procedure is doubtless desirable from the manufacturer's and also from the user's standpoint, if it can be done, as it results in one type of locomotive for any service, but there is no indication, from my experience, that electric motive power puts us any nearer this desirable end than does steam motive power. It certainly seems a mistake for engineers in this early stage of heavy electric-railroading development to come to the hasty conclusion that one standard type of electric locomotive must be advocated for every service, especially when experience in the operation of steam as well as electric locomotives seems to indicate the desirability of combining the elements as I have before indicated to obtain best tracking results.

It must be remembered that track maintenance is a very large item in the cost of operating the railroad, and that track on the average railroad is not always in the best physical condition; therefore the locomotive designer should coöperate

with the track department and not proceed independently in developing the best type of locomotive for any particular local conditions. I should put the prime considerations in determining the serviceability of an electric locomotive as follows:

It should have capacity for the given service.
Electrically and mechanically it should be operative.
It should be least destructive to track, especially when track is not usually kept in perfect surface.
Simplicity and low cost of maintenance.
Low first cost.

For high-speed service especially I would reverse the order which Mr. Batchelder gives under the heading Power Efficiency, for the different manners of mounting motors and connecting them to the driving axles.

In concluding, Mr. Batchelder suggests that it would be interesting to "see a complete investigation of different types of locomotives that are now operating in the same kind of service of different railway terminals in New York City, etc." This certainly would be interesting and should be valuable. I have repeatedly urged such a comparison and suggested that it include not only a comparison of the actual upkeep of the locomotives but should be made to bring out the relative overall upkeep of the railroad. The experimental form of track I have before alluded to could probably be made available for experiments by the coöperation of the various railroads interested if we could secure some concerted action looking to the inauguration of a series of tests. We know now, from figures obtained over a number of years, that there is practically no difference in the cost of locomotive upkeep between such widely divergent types, for instance, as the New York Central and the Pennsylvania Terminal locomotives, and it would therefore be useful to bring out clearly by test what other differences, if any, there are in overall adaptability to influence the future design of a form of motive power of growing importance.

C. H. QUEREAU.[1] In the main I agree with the conclusions reached. However, it seems to me very unfortunate that this paper, as well as others recently presented, is a general statement of the conclusions of the author rather than a statement of accomplished results. There should now be available accurate figures based on actual operation, which should not be held back because of mistaken ideas on the part of those who have the facts or those who have the authority to make them public. That Mr. Batchelder appreciates this, is shown by the last paragraph of his paper.

In Mr. Batchelder's paper, in the list of features arranged in the order of their importance, I would add "Maintenance" under Item 4. It would then read "Convenience of Arrangement as Affecting Safety, Efficiency of Operation and Maintenance." It is quite probable that convenience of maintenance was in the author's mind, but it seems to me of sufficient importance to be mentioned specifically.

In the discussion under the heading "Safety of Operation," I must confess that I cannot quite follow, probably because I do not clearly understand what was written, or have not the information on which the author bases his discussion. For instance, in describing the action of a locomotive having two driving axles guided by a two-axle swivel truck when entering a curve the statement is made that "The flange of the leading wheel gradually comes in contact with the outer rail, giving the guiding truck an angular motion about its outer rear wheel." I have believed that the angular motion of a four-wheeled truck was about its inner rear wheel, the fact being that when a truck is on a curve the outer-forward-wheel flange and the inner-rear-wheel flange are against the rail, the other two flanges not touching the rail. I do not see, however, that this difference is of particular moment and bring it up only that the matter may be discussed and clearly understood.

I believe it will be generally agreed that the operating advantages gained by having electric locomotives designed to operate in either direction is of so great importance that means must be found to provide satisfactory designs to meet this condition, notwithstanding the fact that the effect of the trailing engine truck contributes to unstable riding of the engine. The paper proposes to prevent this oscillation by the introduction of resistance against swiveling. This is practicable and has been so demonstrated, but results in increased flange wear, at least when the center of gravity is low.

As to reliability in service, we have had a number of papers describing the operation of electric locomotives on steam railroads, the design of the locomotives and the description of power plants and transmission lines, but reliability in service usually has been overlooked. In eastern territories, especially around the large cities, a delay of a very few minutes will upset the smooth operation of the railroad for hours and the effect of it reach back on the line for 150 miles. The prevention of such delays is worth considerable increase in first cost, and the maintenance methods should be such as to prevent delays practically regardless of cost; it is decidedly poor policy to reduce maintenance costs if by so doing the result is increased delays.

Mr. Batchelder very wisely considers the cost of maintenance of permanent way of more importance than cost of maintenance of locomotives. It is extremely difficult to state definitely what, if any, effect the electric equipment has on the cost of maintenance of permanent way. If the cost of maintenance of way is no greater under electric than under steam operation, such a condition would undoubtedly not be used as an argument against electrification.

As to the cost of maintenance of electric locomotives, the difference in cost-of-maintenance charges at the rate of 3.5 cents a mile and seven cents a mile may be safely figured as not less than $1000 per engine per year. This saving, capitalized, represents a considerable sum, and would warrant an appreciable increase in first cost to secure it.

In discussing a paper on the mechanical design of electric locomotives we must recognize the fact that there is no common fund of experience or knowledge from which to draw evidence in reaching conclusions, as there is concerning steam locomotives. Opinions and theories are essential in designing radically new electric equipment, but only conclusions based on extended service results are authoritative. No one has had the advantage of experience with more than one type, therefore, one's conclusions as to other types are based on opinions and theoretical considerations rather than actual results as shown by service records.

So far as I know the published data on service results are very limited, either as to first cost or maintenance or reliability in service as shown by train-delay statistics, and therefore each person will place the emphasis on some particular feature, rather than considering results as a whole. If it were possible for this Society, as a neutral, to obtain statistics covering the main points as to results in service, extending over several years, and make them public, it would be of very decided value.

[1] Superintendent of Electric Equipment, N. Y. Central R. R., New York.

The New York Central electric locomotives are all equipped with bi-polar, gearless motors mounted directly on the driving axle. The operating results have been completely satisfactory to the officials of every operating department affected. This statement does not include the net financial returns from the investment, which must take into account the item of fixed charges. With the usual maintenance these locomotives ride satisfactorily and without undue effect on the track structure, and are perceptibly more comfortable than steam locomotives. In order to secure these results it is necessary to keep the total lateral motion, both in the boxes and center pins, within three-quarters of the allowable lateral motion on steam locomotives. Table 1 contains statistics which will permit a personal conclusion as to the reliability of these locomotives in service, which will probably be more satisfactory than any expression of opinion.

TABLE 1 TRAIN DETENTIONS DUE TO DEFECTS IN ELECTRIC LOCOMOTIVES

	Miles Per Detention—All Locomotives		
Year	Mechanical	Electrical	Grand Total
1912	48271	103967	32965
1913	27873	86716	21093
1914	35625	57395	21981
1915	53720	107440	35813
	Type S Locomotives		
1915	59583	187260	45201

NOTE: All detentions of two minutes or more included. In 1913 and 1914 there was a total of sixteen Class T locomotives placed in service. In 1912 there were 47 locomotives in service. Since the middle of 1914 there have been 63. Detentions due to man failure, or delays to following trains, not included.

In this connection I wish to enter a strong plea for the use of Miles per Detention instead of Miles per Minute Detention as the unit in the preparation of statistics by which to judge the reliability of equipment in service and the efficiency of the organization responsible for maintaining it. Including the time element leads only to confusion.

TABLE 2 INSPECTION AND REPAIRS OF ELECTRIC LOCOMOTIVES

	Cost, Cents per Mile		
Year	Labor	Material	Total
1912	1.888	1.460	3.348
1913	1.982	1.454	3.436
1914	2.155	2.134	4.286
1915	1.901	1.379	3.280

NOTE: The above statistics were compiled in accordance with the requirements of the Interstate Commerce Commission. In the year 1914 it was necessary to replace all driving-wheel tires because of unsuitable material, regardless of the extent to which they had been worn. The costs of maintenance have been essentially as above since 1907, omitting 1914.

The figures in Table 2 include the cost of inspection and maintenance of all the electric locomotives, both road and switch. In 1912 and 1913 approximately half the total engine mileage and in 1914 and 1915 approximately one-third was that of engines used in switching service. The cost of maintenance of engines in switching service is about twice that of those used exclusively in road service. It follows that the cost of maintaining the road locomotives has been about 2.5 cents per mile and that of the switch engines about 4.8 cents per miles. These engines were not designed for switching service; bearing this in mind, they have given remarkable results.

For the first ten months of 1916 the average cost of maintenance of all the electric locomotives has been 2.73 cents per mile. This gives a cost of approximately four cents per mile for the locomotives in the switching service and approximately two cents per mile for those in road service. I expect these costs will not be exceeded for the entire year 1916, but very much doubt that we will be able to keep the maintenance costs permanently at this level.

CLOSURE OF MR. BATCHELDER

A. F. BATCHELDER. One point I want to bring out is the desirability of having more weight on the rail at the place of the thrust. That place, by actual test, is at the rear truck. That is not from guesswork, or from theory, or from calculation, but actual fact, tested and observed for 50,000 miles of running, for the particular purpose of finding out the effect of a double-end locomotive on the track. I have witnessed rails displaced three-quarters of an inch by the rear truck when the leading truck did not appear to move the rail at all. The speed at this time was in the neighborhood of 80 m.p.h.

The double-end locomotives I have seen run did not oscillate from side to side when running on curved track, but would hug one side or the other and ride steady; on tangent track, however, they would oscillate from side to side, except when the truck was held from swiveling in the track, in which case the locomotive would run steady just as it did on the curves.

Regarding Mr. Fowler's tests, they seem to agree with the paper, as the steam locomotive with its rigid frame carried directly on springs and with its center of gravity the same height as the car carried on low center pins, did not give as great a thrust. The car would give the effect of a low center of gravity because the side thrust was taken first against the center pin which was relatively low, resulting in less vertical pressure, while the locomotive has a greater vertical pressure due to the side thrust being taken directly and down through the side springs to the rail.

I have never seen any trouble on a curve with double-end locomotives except where too large resistance was used against the trucks curving. A double-end engine, according to my experience, is absolutely smooth and good running on a properly elevated curve.

In regard to Mr. Quereau's remarks as to the pivot point of a truck, I would say that I have not made tests to determine this, but as the outer wheels are heavier, due to the centrifugal and curving forces applied at the center pin, I have assumed that it would pivot about the heavier wheel.

I am gratified to note that Mr. Quereau has furnished figures which bear witness favoring locomotives of the simple and efficient design, and hope that these figures and what Mr. Quereau has to say about the operation and maintenance of these locomotives will have careful consideration by those interested. Mr. Quereau has spoken about the resistance tending to prevent the guiding trucks from oscillating results in increased flange wear, and I believe that Mr. Quereau is right. With the engines Mr. Quereau has in mind, there is a frictional resistance of an amount that once the truck has taken a position some external force is required to put it into another position, and it might therefore run cock-eyed on the track and cause flange wear. In that particular case flange wear is much preferable to oscillation.

Mr. Katte has spoken of coil springs on the journal boxes, and I would add that my experience with them has been gratifying.

Mr. Young has understood me to say that a locomotive will not run backward safely. I would rather modify that statement and say that it is not desirable to run it backward. For that matter, I do not know of any locomotives of the American type operating at 80 m.p.h. backward.

Mr. Eveleth has been associated with me throughout a large portion of his experience with electric locomotives, and his discussion favors the conclusion of the paper.

Replying to Mr. Gibbs's written discussion, I would say

that Mr. Gibbs seems to agree with me as to the importance of the high center of gravity in steam locomotives; however, it seems to be an inherent condition in steam locomotives, and if it were not desirable it would be difficult and expensive to reduce it any considerable amount.

It is also desirable to have the dead weight below the springs as little as possible, especially in steam locomotives where the unbalancing, due to reciprocating parts, adds relatively large values to the vertical impact. It is not uncommon in well-designed high-speed steam locomotives to have the dead weight on some axles 13,000 or 14,000 lb., and to this is added the effect of the unbalancing, due to the reciprocating parts. A careful analysis of this will show that these values are considerably in excess of the dead-weight values on high-speed electric locomotives of the design suggested in the paper as best adapted for this service, which has been built up to the present time. The last locomotives of this type built for the New York Central R.R. to handle 1200-ton trains at 60 m.p.h. has a maximum of 6310 lb. dead weight per axle.

Again Mr. Gibbs agrees with me in that we should not abandon any of the important principles that have been found good in steam practice. I would add, however, providing it is possible to retain the principle in its desirable form. I believe the paper has made it clear that the high center of gravity cannot be used to the same advantage in double-end-operating locomotives with trailing trucks as with a single-end steam locomotive, unless special provision is made in the design of the truck, in which case it matters not whether the center of gravity is high or low.

Relative to the unsymmetrical wheel and weight distribution in double-end-operating locomotives, I am unprepared to agree or disagree with Mr. Gibbs, but, offhand, I would say that within the possibilities of locating the weights, the effect would be slight and could be easily overcome by the design of the guiding trucks.

As to Mr. Gibbs's "A word more about the high center of gravity," and how electrical designers secure the high center of gravity, I wish to repeat that it does not make any difference whether the center of gravity be high or low, or how it is obtained, if the locomotive is provided with guiding trucks at each end (the locomotive is guided at its ends and not in the middle), and, as stated in the paper, the trucks can be designed to obtain the results required.

The testing device that Mr. Gibbs describes is extremely interesting and very valuable in determining certain characteristics, such as the transverse movement required in the trucks and measuring the transverse pressures tending to displace the rail, but it does not determine whether or no the locomotive is destructive to the track or safe to operate, as it makes no record of the vertical pressure which affects the adhesion between the rail and tie, which Mr. Gibbs apparently deems important and which I believe is one of the most important features to be obtained.

It is not the intention of the paper to convey the idea that it is necessary to have leading trucks for the successful high-speed locomotive, but to say that with leading trucks the desired results can be obtained.

Relative to the desirability of operating single-end locomotives backward, I am quite content to leave this with those who have had experience in operating.

Relative to gearing locomotives to obtain satisfactory results for high- or low-speed service, I would say that this is done very effectively on several roads, and the results indicate that it is very good practice.

THE FLOW OF STEAM AND AIR THROUGH ORIFICES. HERBERT B. REYNOLDS

G. B. UPTON. Inspection of the paper as to conditions of measurement shows (1) that pressures were taken in the dead eddies close to the orifice plate, above and below; (2) that orifices were small compared to pipe diameter, the largest ratio being with a ½-in.-diameter orifice in a 2-in. pipe; (3) and that pressure drops were large, generally all or nearly all of the excess of pressure P_1 above atmosphere being used to cause flow. The author did not touch, nor intend to touch, on the experimental case of a thin-plate orifice, large compared to pipe and pressure drop small compared to initial pressure, that is, the conditions which would make the thin-plate orifice a competitor of the venturi tube as a measuring device.

The usual formula for flow of gases or vapors through a venturi is

$$W = C F_2 \left(\delta_0 \frac{T_0}{P_0} \frac{2gy}{(y-1)} \right)^{1/2} \left(\frac{P_1}{T_1^{1/2}} \right) \left\{ \frac{(1-x)^{2/y} - (1-x)^{(y+1)/y}}{1 - a\,(1-x)^{2/y}} \right\}^{1/2} \quad [1]$$

In this equation the units are in the foot-pound-second system. W is the flow in pounds per second; C the "coefficient" of the venturi; F_2 the area of the throat of the venturi; δ the density in pounds per cubic foot; y the ratio of specific heats at constant pressure and constant volume for the gas or vapor; x the ratio of the "venturi head" (or drop in pressure from entrance to throat of the venturi) to the driving pressure at entrance, or $x = \Delta P/P_1 = (P_1 - P_2)/P_1$; and a the square of the area ratio F_2/F_1. Subscripts 0 refer to standard conditions for the gas; subscripts 1 and 2 to entrance and throat of the venturi, respectively.

In an article by the discussor in the *Sibley Journal of Engineering* for December, 1914, pp. 90-95, it was shown that the venturi formula [1] could be replaced by

$$W = C F_2 \left(\frac{2g\ \delta_0\ T_0}{P_0\,(1-a)} \right)^{1/2} \left(\frac{P_1 \cdot \Delta P}{T_1} \right)^{1/2} \left(1 - \frac{3+a}{4y(1-a)} \cdot \frac{\Delta P}{P_1} \right) \quad [2]$$

or

$$W = C F_2 \left(\frac{2g\ \delta_0\ T_0}{P_0\,(1-a)} \right)^{1/2} \left(\frac{P_1 \cdot \Delta P}{T_1} \right)^{1/2} \left(1 - \frac{(3+a)}{2y(1-a)} \cdot \frac{\Delta P}{P_1} \right)^{1/2} \quad [3]$$

The accuracy of this simplified formula was shown to be within one per cent, even for the largest values of $\Delta P/P_1$, if we remember the "critical" value of P_2 with regard to P_1 for gas expansion, and the variation of nozzle coefficients with flow when ΔP is large compared with P_1.

To compares equation [3] with that of Reynolds, we must change to the same units. W of [3] changes to Q of Reynolds' formula by multiplication by 60 δ_0. P and ΔP values of [3] change to corresponding values of Reynolds' formula by multiplication by 144. F_2 of [3] must be multiplied by 144 to reduce to inches. C may be taken as unity. δ_0 for air = 0.0807; T_0 = 492 deg. fahr.; P_0 = 14.7, and $\sqrt{(2g)} = 8.02$. Hence the reduced formula obtained from [3] is

$$Q = \frac{816\ F_2}{\sqrt{1-a}} \left(\frac{P_1 \cdot \Delta P}{T_1} \right)^{1/2} \left(1 - \frac{(3+a)}{2y\,(1-a)} \cdot \frac{\Delta P}{P_1} \right)^{1/2} \quad [4]$$

The orifices used by Reynolds ranged from ⅛ in. to ½ in. in diameter, in 1½-in. or 2-in. pipes. Taking a 3/16-in. orifice in 2-in. pipe as typical, the ratio of orifice area to pipe area is $(3/32)^2$. There is a contraction of area of the flow beyond the thin-plate orifice, on the low-pressure side, with a "contraction coefficient" (K) which most probably lies near 0.60, and must be between 0.60 and 1.00. The reason that we cannot take K as 0.60 is that when the pressures are measured, as Reynolds did, close up to the orifice plate, the pressure drop

is slightly less than if it were taken exactly at the section of minimum area of flow below the orifice. This smaller pressure drop we compensate for in our calculations by using a value of K larger than its true value, which is somewhere near 0.60. The effective value of K may be 0.70 or 0.80.

It is the contracted flow beyond the thin-plate orifice which really corresponds to the throat of a venturi. The area ratio from pipe size to throat size is $K(3/32)^2$; and assuming $K = 0.75$, the factor a in the venturi formula is $0.75^2\ (3/32)^4 = 0.000043$. This is so near to zero as to be negligible. The value of y for air is 1.40, under ordinary pressures and temperatures. On account of the contraction of flow beyond the orifice the value of F_2 in the venturi formula is KA, A being the area of the orifice. With these values inserted in formula [4] it becomes

$$Q = 816\ KA \left\{ \frac{P_1 \cdot \triangle P}{T_1} \right\}^{1/2} \left\{ 1 - \frac{3.00}{2 \times 1.40} \cdot \frac{\Delta P}{P_1} \right\}^{1/2} \text{ or}$$

$$Q = \frac{816\ KA}{\sqrt{T_1}} \left\{ P_1 (P_1 - P_2) \left(1 - 1.072 \frac{(P_1 - P_2)}{P_1} \right) \right\}^{1/2} \text{ or} \qquad \ldots [5]$$

$$\frac{Q = 816\ KA}{\sqrt{T_1}} \left\{ (P_1 - P_2)\ (-0.072\ P_1 + 1.072\ P_2) \right\}^{1/2}$$

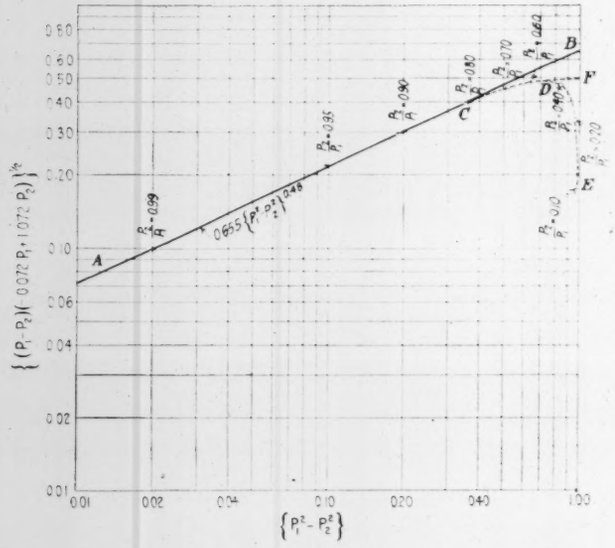


FIG. 1 COMPARISON OF REYNOLDS AND VENTURI FORMULAE

The expression $\{ (P_1 - P_2)\ (-0.072\ P_1 + 1.072\ P_2) \}^{1/2}$ is obviously not convertible by algebraic transformation into anything much like Reynolds' expression $(P_1^2 - P_2^2)^{0.48}$, which may be written for comparison as $\{ (P_1 - P_2)\ (P_1 + P_2) \}^{1/2}$. Dropping the attempt to make a direct conversion of one formula into the other, we may test to see whether there is some constant ratio between the two expressions $\{ (P_1 - P_2)\ (-0.072\ P_1 + 1.072\ P_2) \}^{1/2}$ and $(P_1^2 - P_2^2)^{0.48}$. Table 1 and Fig. 1 show the comparison and its results.

The figures in Table 1 are plotted in Fig. 1. The line AB has the equation $0.655\ (P_1^2 - P_2^2)^{0.48}$. Up to the point C it fits nicely the values calculated from the modified venturi equation. The venturi values then go down CDE; but the venturi equation is here wrong because the values of P_2 are below the critical. The actual values would follow out the general direction CDF rather than CDE. If we remember that the contraction coefficient of the orifice is a function of P_2 and $(P_1 - P_2)$, it will be evident that the expression $0.655\ (P_1^2 - P_2^2)^{0.48}$ may be a very good fit to experimental values of flow throughout the entire range of pressure and pressure-drop values.

Putting the expression $0.655\ (P_1^2 - P_2^2)^{0.48}$ in place of $\{ (P_1 - P_2)\ (-0.072\ P_1 + 1.072\ P_2) \}^{1/2}$ in equation [5], there results

$$Q = \frac{0.655 \times 816\ KA}{\sqrt{T_1}} \left\{ P_1^2 - P_2^2 \right\}^{0.48} = \frac{534\ KA}{\sqrt{T_1}} \left\{ P_1^2 - P_2^2 \right\}^{0.48} \qquad \ldots [6]$$

Reynolds' expression makes the coefficient of A to be 405. For this to be so, it is necessary that K have the value $405/534 = 0.758$, which, as has been pointed out above, is both possible and reasonable. The conclusion is that Reynolds' empirical formula agrees as well as can be expected with the mathematical calculations of the flow of air under the circumstances of his measurements.

TABLE 1 COMPARISON OF REYNOLDS AND VENTURI FORMULAE

Argument, P_2 (P_1 taken as unity)	Values of expressions $[(P_1 - P_2)(-0.072\ P_1 + 1.072\ P_2)]^{1/2}$	$(P_1^2 - P_2^2)^{0.48}$	Ratio	Remarks
0.99	0.09945	0.1526	0.652	
0.95	0.2175	0.3271	0.665	
0.90	0.2971	0.4506	0.659	Above
0.80	0.3964	0.6122	0.647	critical
0.70	0.4512	0.7238	0.623	pressure
0.60	0.4780	0.8072	0.592	
0.40	0.4627 (0.490)	0.9187	0.504 (0.533)	Below
0.20	0.3375 (0.495)	0.9806	0.344 (0.499)	critical
0.10	0.1780 (0.500)	0.9951	0.179 (0.503)	pressure

CLASP BRAKES FOR HEAVY PASSENGER EQUIPMENT CARS

T. L. BURTON

O. C. CROMWELL. In about 1912 the Baltimore & Ohio Railroad, along with other railroads, began to replace wooden passenger-equipment cars with all-steel cars of greater length and heavier weight, and with these cars more or less difficulty was experienced in the proper controlling of the speed and braking of the trains, necessitating very close and frequent adjustment of the brake apparatus on the trucks.

In 1914 the Baltimore & Ohio Railroad again purchased a number of passenger-equipment cars, including 60-ft. steel smokers with 4-wheel cast-steel trucks, steel coaches, passenger and baggage, baggage and mail and baggage cars with 6-wheel cast-steel trucks and weighing about 135,000 lb., and 73-ft. dining cars weighing about 157,000 lb. Clasp brakes were applied, and the clasp brake is now considered the standard brake for this class of equipment.

As passenger equipment cars become larger, the question of increasing the size of cylinders and the brake apparatus has become quite a serious one. Relief has been found in the use of clasp brake, in that while an 18-in. diameter cylinder may be used on cars with maximum weight of 143,000 lb. with single-shoe brake-beam type of truck, however, with clasp brakes a maximum weight of 153,000 lb. is allowed.

The clasp brake prevents the rapid accumulation of piston travel and consequently enables a larger-diameter cylinder to be used. The old-style brake with a standing piston travel of 6 in. has a running travel of 7½ in., a difference of 1½ in.,

while the clasp brake with a standing travel of 6 in. has a running travel of 6¾ in., a difference of ¾ in.

The location of the shoe of the clasp brake in relation to the wheel, namely on the horizontal center line, prevents the rapid accumulation of slack, and consequently piston travel, while the old-style brake beam with the single shoe located some distance below the center line caused rapid wear and accumulation of slack which was reflected in the piston travel.

With the single-shoe brake beams on the heavier trains on long grades, when the brake shoes were wearing thin, the shoes have been found fused to the heads due to the heat generated by the long application of brakes. This condition does not obtain with the clasp brake.

With the clasp brake journal bearings wear more uniformly and do not crowd to the side, as in the case of single-shoe brakes. It has also been found with the clasp brake that there is less wear on the pedestal jaws and the journal boxes and the shoes, and when starting out from a terminal shoes can be permitted to go on a run worn as much as ¼ in. thinner than in the case of the single-shoe application. We feel that on the heavier-passenger-equipment cars the clasp brake will shortly be found in almost universal use.

The reduction in the number of hot boxes on passenger-train cars which has taken place since the application of clasp brakes is not claimed to be due wholly to the clasp brake, but it has contributed its share to the improvement.

B. P. FLORY. The conclusions which are arrived at in the paper are borne out by practical experience of roads which have cars equipped with clasp brakes in service. On the New York, Ontario & Western Railway we have 12 all-steel cars weighing 106,000 lb. with four-wheel trucks equipped with clasp brakes since May, 1914. There has been no trouble experienced in the operation of the brakes on these cars and we have noticed all of the things to which Mr. Burton calls attention. These cars run in train with other cars which have the single brake, and the difference in riding of the cars when stopped is very noticeable.

As to hot boxes, we find that for a period of 30 months, the cars making in that time a mileage of 1,873,500, there have been 10 hot boxes, mostly due to new wheels and axles. During the same period the balance of our passenger cars had 88 hot boxes with a mileage of 11,507,200, or an average of 130,769 miles per hot box against an average of 187,350 miles for the cars equipped with clasp brakes.

Mr. Burton's conclusion concerning the use of clasp brakes in order to stop trains in a short distance should be in the mind of every railroad official when the question of new equipment is raised. This is recognized, for in 1915 the Master Car Builders' Association adopted as recommended practice, the rule that all passenger cars with four-wheel trucks weighing 96,000 lb. and over, and all passenger cars with six-wheel trucks weighing 136,000 lb. and over should be equipped with clasp brakes.

C. B. SMITH[1]. The subject has been so thoroughly covered by the author, who is the "father of clasp brakes," as to leave little either to criticize or add. To the advantages which the author has stated it might be added that the clasp brake has accomplished more successfully that which was previously sought for by the adoption of the brake-slack adjuster, i.e., taking up slack due to shoe wear as well as other lost motion in the brake rigging and trucks. The slack adjuster now becomes a necessary adjunct to the clasp brake and will perform its functions as intended.

Our limited experience with the clasp brake confirms all that the author claims. No new passenger equipment will be constructed without this valuable improvement. Moreover, with its adoption upon important train equipments the way is opened for one of the next desirable improvements in brake mechanisms, i.e., that which will justify producing simultaneous application as well as release of brakes on all cars of the train, which can be done with the electric-control device. The use of the clasp brake on all the cars in an entire train will not completely eliminate possible rough handling because of the time interval between head- and rear-end application.

[1] Boston & Maine R. R., Boston, Mass.

THE TALBOT BOILER. PAUL A. TALBOT

D. K. WARNER[1]. I should like to ask Mr. Talbot if any experiments have been made since those conducted by the U. S. Geological Survey on the temperature of the tube metal in a boiler of natural gravity circulation. Those tests showed that the tube temperature remained practically that of the water in the tubes. As the capacity for receiving heat depends only on the temperature difference between the tube and the gases, and the velocity of the gases, I would take exception to Mr. Talbot's statement that "the high rate of evaporation is obtained because of the high velocity of water in the tubes." Inasmuch as with ordinary circulation the tubes keep as cool as the water, it would seem that the high capacity of this boiler is due more to the high furnace temperature, the absence of baffles and other special features. I would also like to ask if the periodic temperature variations mentioned would be great enough to injure a turbine.

Because of its freedom of expansion this boiler seems admirably suited for very high capacities. May I ask the author then why he limits himself to a draft of two inches of water. Using 20 lb. of air per lb. of oil, a draft of 24 inches of water requires by theory less than 1½ per cent of the power developed in the turbo-generator. Electric fans are built of 50 per cent efficiency, so that it would actually require but 3 per cent of the power. High capacities will be essential on the new ships of such great power and the flue temperatures can be kept down by adding a few layers of tubes.

[1] Sheffield Scientific School, New Haven, Conn.

A Norwegian shipbuilding concern, according to *The Times Engineering Supplement* (Jan. 26, 1917), is about to construct a reinforced-concrete ship of 3000 tons dead-weight capacity which is to be fitted with Diesel engines for propulsive purposes. Hitherto the use of this material has been restricted to small vessels.

The coefficient of friction of bronze on bronze has been the subject of some recent experiments by the U. S. Reclamation Service. The tests were conducted on the slide-gates at the Pathfinder, Arrowrock, and Elephant Butte dams. The head on the center of the gates varied between 50 ft. and 125 ft. The average coefficient of friction of the opening stroke ranged between 0.31 and 0.42 for the different dams. The maximum ranged between 0.383 and 0.44. The average for the closing stroke ranged between 0.254 and 0.29 and the maximum between 0.268 and 0.34. (*Western Engineering*, vol. 8, no. 2, February 1917, p. 51).

LARGE RECLAMATION PUMPING PLANT

Discussion by Louisiana Engineers of the Details of Design of the Largest Drainage Pumping Plant in California

A JOINT meeting of the Louisiana Society of Members of the American Society of Civil Engineers and of the New Orleans Section of The American Society of Mechanical Engineers, held on October 2, 1916, was devoted to the discussion of a paper entitled The Design and Test of a Large Reclamation Pumping Plant,[1] by G. C. Noble, of San Francisco. This discussion is published below, preceded by a brief abstract of the paper, which is given here for the purpose of reference.

The paper by G. C. Noble, purchasing engineer of the Shell Company of California, entitled The Design and Test of a Large Reclamation Pumping Plant, originally presented at a meeting of the San Francisco Section of The American Society of Mechanical Engineers, published in the May 1916 issue of The Journal and later presented at the Thirty-Seventh Annual Meeting of The Society in December 1916, was also discussed at a joint meeting of the New Orleans local association of the American Society of Civil Engineers and the New Orleans Section of The American Society of Mechanical Engineers on October 2, 1916.

Mr. Noble's paper dealt with drainage problems involved in Reclamation District 1500, one of the largest in the state of California, the solution of which problems resulted in the construction of the largest reclamation plant in this country; and what the New Orleans engineers had to say regarding the California project makes interesting reading. Also, the discussion here presented brings out incidentally a number of valuable points in connection with present drainage practice in Louisiana.

ABSTRACT OF PAPER

During the last few years there has been a very rapid development in reclamation work along the rivers of California, with a decided tendency towards the formation of very large districts. To accomplish true reclamation it is necessary not only to exclude the flood or overflow waters, but also to provide a drainage and pumping system which will insure the removal of all surface water, whether from rainfall or seepage, as fast as it accumulates. Failure to do so will result in a very great loss, and it is therefore imperative that the system be designed in accordance with the best engineering practice.

In this paper the author outlines the problems involved in the case of Reclamation District 1500, commonly called Sutter Basin, one of the largest in the state of California, the solution of which has resulted in the construction of the largest reclamation pumping plant in this country, having six 800-hp. units. The District has an area of about 66,000 acres, and to reclaim the tract it was necessary to surround it with some 70 miles of levees.

The author first describes the methods employed in determining the amount of drainage water due to run-off from rainfall and to seepage through levee banks, to be handled by the pumping plant, and after a study of data dealing with the maximum pumping head, concludes that the plant capacity should consist of pumps that can lift 1000 sec-ft. against a 29-ft. head.

As the plant was accessible to three electric-power companies, it was decided to use motor-driven centrifugal pumps; six units, each a 50-in. pump having a normal capacity of 175 sec-ft. against a discharge head of 29 ft. and driven by an 800-hp. motor, being decided on as offering the most satisfactory arrangement and best economical design. Power is delivered at 2200 volts from three 1500-kva. outdoor-type oil-cooled transformers receiving energy at 60,000 volts.

Inasmuch as the district would be flooded the first year after installing the plant on account of non-completion of the levees, and also as a protection against damage to pumps from flooding due to possible breaking of levee at high water, it was necessary to design the walls of the (reinforced-concrete) pumping-plant building to withstand a depth of water on the outside of 18. ft. above floor level, which resulted in the use of walls 4 ft. 6 in. thick at the base of the floor line. The uplift pressure on the bottom of the building amounted to nearly 5000 tons.

Results of preliminary tests on one unit are embodied in the paper in a chart, which shows a combined motor and pump efficiency of very nearly 60 per cent at a discharge of 165 sec-ft. and 29 ft. head.

MR. OKEY DISCUSSES THE DETERMINATION OF THE PROPER CAPACITY OF A PUMPING PLANT

CHARLES W. OKEY.[1] The determination of the proper capacity of a pumping plant to remove the drainage water from a given district is the most important step in its design, for the main purpose of the drainage district is agriculture and not pumping water. A pumping plant might be correctly designed as to economy and reliability of operation, yet might be too small to give the district adequate drainage. The loss of even a portion of one crop on the district might easily exceed the entire cost of a plant of sufficient capacity to insure drainage at all times. This fact has been recognized in a number of places where drainage is secured by pumping, and the present tendency is towards larger relative capacity. This additional money spent in a pumping plant is looked upon by the owners of the land as an insurance policy against loss by floods. In addition, the greater feeling of security given by a pumping plant much larger than those around it has resulted in a rise in land values in districts served by extra-large pumping plants over those not so well protected.

The method Mr. Noble has used in arriving at the proper capacity of pumping plant looks reasonable, except that his assumption of 25 per cent as the proportion of the rainfall that will run off is apparently too small. The heaviest rainfall

[1] The Journal, May 1916, page 371.

[1] Senior Drainage Engineer, U. S. Dept. of Agriculture,, Tulane Univ., New Orleans, La.

comes during the winter season when the evaporation is at a minimum. At similar times the percentage of rainfall appearing as run-off has been as high as 75 or 80 per cent on the districts in Louisiana. The plant capacity as he has designed it is about 0.40 in. per 24 hours. The main drainage channel has a storage capacity slightly over 0.20 in. During the storm period of January 12 to 15, 1911, when 5.16 in. of rain fell, the pumping plant and reservoir canals would have been able to take care of a depth of 1.80 in. over the entire watershed, provided the canals were empty when the rain started. This would have been about 35 per cent of the total rainfall. If the land were saturated when this storm started, from comparison with results in Louisiana, this capacity appears to be rather small. However, most of the studies on the districts in Louisiana have been made on much smaller ones than that mentioned by Mr. Noble. As a result, two, or possibly three, days should be added to the period over which pumping occurred. Assuming as he did that the reservoir canal would be empty on January 13, and would be empty again on January 17, the total amount pumped would be about 2.00 in., or nearly 40 per cent of the total.

Even if it were considered that only 60 per cent of the total rainfall had to be handled in five days, starting on January 13, the capacity of the pump would have had to be 0.60 in. per 24 hours. Looking at the question from the side of the investor or actual cultivator of the land, this additional safeguard might be justified.

Present practice in Louisiana is to install a capacity of about 1.50 in. on districts of about 4000 or 5000 acres, where the reservoir capacity is perhaps 0.50 in. Of course the rainfall is much heavier, but this would provide for a much larger percentage of run-off than provided by Mr. Noble. It is to be hoped that records of operation of this plant will be kept, so that future districts will have some actual data on which to base the design of capacity.

MR. HUTSON DISCUSSES THE DISPOSITION OF DISCHARGE PIPES FOR VARIOUS SUBSOIL CONDITIONS

H. L. HUTSON. We should not, in my opinion, compare this plant, with its high lift, with our local drainage projects. Mr. Noble's problem is more nearly comparable with our irrigation plants of Western Louisiana and Texas than with our low-lift drainage plants of the coast country. It is also similar to the drainage projects of Iowa and Illinois, but with somewhat higher lift.

Whether or not it is the best practice to have the discharge pipes pass through or over the levee is, to my mind, a question to be decided with a full knowledge of the strata beneath the plant. If the plant rests on impervious strata, there is no reason why it should not be set in the levee and the pipes pass through the latter, for with a plant of this size acting as a core wall, there would be no danger of leakage along the pipes, endangering the levee. In fact, the plant itself may act as a dam, just as do most of the city drainage plants in New Orleans, and as in the case of some of the irrigation plants in Texas.

If there is only a thin stratum of porous material beneath the plant, this may be cut off by a tight bulkhead of sheet piling and the plant designed as if on an impervious foundation, but care should be taken that the bulkhead is long enough to prevent flow around the ends.

If the plant rests on a porous foundation, we must then so design that the seepage through the porous material will be so retarded as to preclude any movement of the porous material. This may be accomplished by placing the suction and discharge basins a sufficient distance apart for the friction through the porous material at a safe rate of percolation to equal the maximum head. The cheapest way to connect these suction and discharge basins is usually by metal pipes, and there is an added element of safety by having the pipes go over the levee.

As has been pointed out several times in articles on dams, a perfectly safe dam may be built on sand or other porous material, provided proper coefficients are used in figuring the length of travel for the water through the porous material. Mr. W. G. Bligh has given the following:

$$L = CH$$

where H = head of water or difference in level of water above and below dam

L = length of travel for water while percolating through the porous material.

For very fine sand and silt	$C = 18$
For fine sand	$C = 15$
For coarse sand	$C = 12$
For sand and gravel	$C = 9$
For boulders and gravel	$C = 4$ to 6.

If there is a line of sheet piling or a cut-off wall extending into the porous material, L may be measured along the course which the seepage would take, namely, horizontally through the porous strata until it strikes the obstruction, then down one side and up the other, the water following the surfaces of the solid material.

By this use of sheet piling the horizontal distance between suction and discharge basins may be reduced. An apron of impervious material on the discharge side of the plant may also be used to cut down the length of discharge pipe necessary. A row of sheet piling on the outer edge of this apron is also helpful. On the other hand, there is no advantage in having the intake paved with a watertight pavement over using rip-rap merely to prevent scour. If the pavement were watertight, there would probably be uplift enough to crack the pavement.

MR. DUSENBURY COMMENTS ON THE HIGH NOZZLE VELOCITY OF THE PUMPS

ALLEN T. DUSENBURY.[1] Pump manufacturers have urged that nozzle velocities should not exceed 6 or 8 ft. per sec. The nozzle velocity in Mr. Noble's pump, at 175 cu. ft. per sec. discharge, is about 13 ft. per sec. I wondered why that was so, and why they did not enlarge the nozzles on the pumps.

The paper states little or nothing about the type of soil and its reservoir capacity throughout the district, so that the amount of run-off cannot be judged. If the soil is like some of the Sacramento Valley land, where the peat bogs are 50 ft. thick, then the matter of building levees is a continuous one. If that is the character of soil, it does not require much pumping capacity to handle the water, because the soil will take care of so much with the small rainfalls in the district.

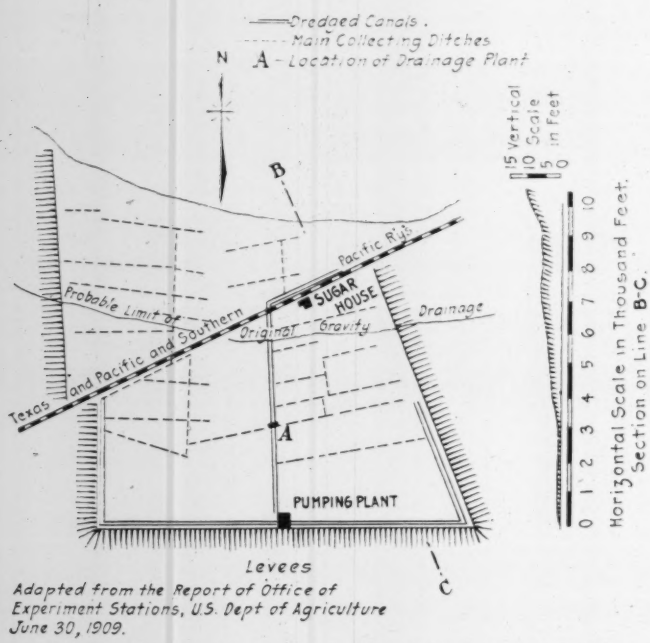
The paper states nothing about the character of the soil under the pumping plant, and does not show how the danger from seepage flow under the plant is overcome. With a difference of head of sometimes 29 ft., there would be a very great tendency for leakage to occur. I presume possibly that, for such high heads, the manufacturers did not advocate the lesser nozzle velocity so much as they do in the low-lift pumps.

[1] Vice-President and Chief Engineer, Louisiana Meadows Co., New Orleans, La.

Mr. Hutson replied to Mr. Dusenbury that the pump manufacturers do change the rating of the pump with the increase of head. He did not know just what was the rule employed, but the higher the head pumped against, the greater capacity would the manufacturers rate their pump at, because a high velocity was necessary in the impeller to pump against that head.

MR. SHAW DESCRIBES DITCHING AND CANAL SYSTEM USED ON A LOUISIANA PLANTATION

A. M. SHAW.[1] In connection with the question raised by Mr. Dusenbury in regard to the soil formation, we know that the Sacramento River is a silt-bearing stream. I am not positive with regard to the Feather River, but the contour lines given on the map in the paper would indicate that this river has also built up a set of natural levees along its banks, and for that reason one would feel almost certain that at the confluence of these two rivers, at which point the pumping plant has been constructed, a silt formation rather than a peaty bog would be found, typical of certain other portions of the Sacramento River Valley.



Adapted from the Report of Office of Experiment Stations, U.S. Dept of Agriculture June 30, 1909.

FIG. 1 WILLSWOOD PLANTATION, ST. CHARLES PARISH, LA., SHOWING CANALS AND MAIN DITCHES

A point to be stressed is the division of the tract being reclaimed into zones, with the idea of bringing the water to the pumping plant in such a manner that it can work to best serve the entire area. That is a method of arrangement of ditches which has not been given sufficient attention in this section. It does not enter into the problem, particularly, of the reclamation of the typical flat prairie lands of the Delta country, but does enter very markedly into the reclamation or the drainage of the river-front lands. We have in the vicinity of New Orleans a number of tracts which are drained artificially, which are the result of evolution from the river-front lands. These were drained by gravity, but finding the back lands more fertile, the owners have pushed back their rear levee and gradually taken in additional land. This new land was too low to drain by gravity, so they have put in pumps on the back levee and drained the entire tract artificially, the result being that the original system of ditches is incorporated in the final system; and on account of the original system having been designed with the idea of getting rid of the water as quickly as possible, it usually dumps the water from the front lands (which are more or less impervious and have a considerable slope) back to the pumping plant, a mile or more away, at about the same time that the nearer water reaches the pumps.

The plan of the author was to divide this into zones, so that the supply of water to be pumped out will reach the plant in a manner which will enable it to serve the entire tract as nearly as possible at an equal rate. It is doubtful if any system of ditches could be designed to serve a tract of this nature in an ideal manner under all conditions of rainfall. As the author states, the elevation of the lowest point in the basin is 19 ft. above datum, and the maximum elevation is 30 ft. above datum. Undoubtedly, therefore, a great deal of benefit is derived by designing the ditches as the paper describes.

It occurs to one reading the paper that a tract of the size of the District and a project of such importance would justify at least a consideration of two separate drainage systems. That is something which should be considered in a number of the reclamation projects along the river front in the locality of New Orleans, and which has been worked out already on a very small scale in a few instances. With the data furnished in regard to the project under discussion, it is impossible to judge whether a separate system of drainage would be justified in that particular instance, but it is interesting to note what might be worked out provided things are as we assume.

A gravity drainage system might be installed following approximately the 24-ft. contour (starting a little above that, so as to get fall for the ditch), and diverting all of the water from the area above that contour to some point which would be reasonably near, if not at, a point which would be suitable also for the main pumping plant of the district. If it could be brought to the same point, all the works could be controlled by the same crew of men that would operate the pumping plant. Such a system would not be operative at times of extreme high water in the Sacramento River, but it is reasonable to suppose that a large proportion of the flood water during a considerable portion of the year could be discharged by gravity, or, if not by gravity, by an independent low-lift pump, at a very much lesser cost per acre of drainage than by allowing the entire flood to drop into the sump, making necessary the maximum lift for the entire drainage.

The two points discussed should be given more attention in the Louisiana drainage projects along the Mississippi River, where we have somewhat similar conditions to contend with.

At Willswood we have a situation about as shown in Fig. 1. The entire tract contains about 2500 acres. The original plantation ran a little over one-third of the distance back from the river.

I believe that the original tract was drained entirely by gravity. As the demand for more land was felt, a levee was constructed as shown in the figure, which enclosed a considerably greater area. This new land was too low to drain by gravity and a drainage wheel was constructed. All the drainage from the older as well as from the new lands was brought to this point and pumped out on the prairies to the rear. The

[1] Consulting Engineer, New Orleans, La.

ditching system was on the regular "checkerboard" system common to the front lands, and this system was extended to the entire final project, which was installed fifteen or twenty years ago.

As will be noted, the entire ditching and canal system is of such a design that drainage water will be rushed to the pumps as quickly as practicable from even the most distant points of the plantation. As the land farthest from the pumps is practically impervious and has a slope of from 2 to 4 ft. per 1000 ft., the effect is to flood the lower lands before the water from even ordinarily heavy storms can be removed—this in spite of the fact that the Willswood plantation has an exceptionally large pumping capacity per acre of area served. The damage from such flooding in the past has not been serious, as the rear lands have usually been planted in cane, and cane will stand flooding for several hours, but the arrangement is not ideal.

An element which we find common in the multiple-unit plants in Louisiana, which does not seem to have been taken advantage of in the plant under discussion, is the variation in the type of pumps and power units. These, apparently, are exact duplicates throughout the entire plant. It is probable that in the case at hand, as well as in those that we have in this section, a very large proportion of the pumping could be done by one or two units, and in a project of that size it would seem reasonable to suppose that those one or two units might be designed for a maximum efficiency. The sacrifice of efficiency for financial reasons is considered, and probably wisely so, but in the multiple-unit plants in this section we find that we can put in one pump of a sort of constant-duty type which will handle a great deal of water over a long period of time with greater economy than the pumps which are put in as purely flood-protection equipment.

MR. NELSON DESCRIBES AN ARRANGEMENT OF PUMP AND DISCHARGE PIPE HAVING SEVERAL ADVANTAGES

B. S. NELSON.[1] With reference to the question of bringing the discharge pipes over the levee, Mr. Noble said that there would be considerable trouble in priming the pumps without the gate valves, due to the long line of discharge pipe.

[1] Engineer for A. M. Lockett & Co., Ltd., New Orleans, La.

It might be of interest to show, Fig. 2, a somewhat similar installation near Pharr, Texas, where we had very much the same conditions, although the plant in question is an irrigation plant. The pump in this installation is about 400 ft. away from the concrete bulkhead of the canal. The discharge pipe is a wooden-stave pipe about 7 ft. in diameter. One end of this pipe connects to this concrete bulkhead; the other end runs back to within a short distance of the pump. On the discharge of the pump we used an ordinary sheet-iron increaser, with an inexpensive flap valve on the end, to recover the velocity head. This valve was about 5 ft. in diameter.

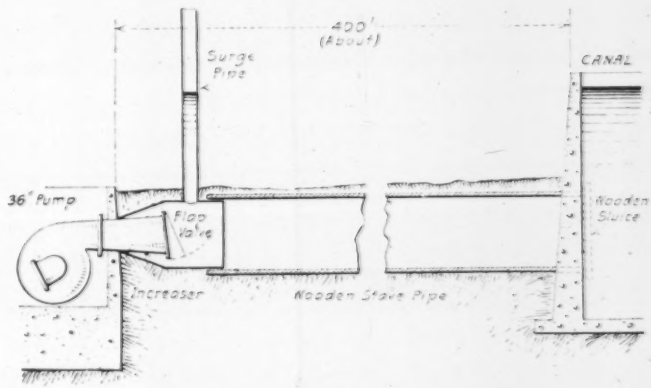


FIG. 2 ARRANGEMENT OF PUMP AND DISCHARGE PIPE USED IN INSTALLATION AT PHARR, TEX.

On the outside of the increaser was riveted a larger cone, one end fastened to the increaser and the other to the wooden pipe.

The advantages of this arrangement were that we recovered the velocity head by using an increaser; we substituted an inexpensive flap valve for an expensive gate valve, and we could prime the pump without priming the long discharge pipe.

There is no trouble about getting at the flap valve, because a sort of wooden sluice gate was arranged which could be let down over the bulkhead end of the wooden pipe and this pipe then drained back through the pump so that workmen could get into it.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members of The American Society of Mechanical Engineers are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal, or brief articles of current interest to mechanical engineers.

Underfeed-Stoker Furnace Action

TO THE EDITOR:

In the course of the discussion of Mr. Victor J. Azbe's paper on Power-Plant Efficiency, presented at the recent Annual Meeting of the Society, the statement was made that the process of combustion in an underfeed-stoker furnace is identical with the surface-combustion process. It was claimed that the short flame resulting from this process of firing was due to an accelerated chemical reaction brought about by the combined presence of the combustible gases with air and the solid fuel bed, interacting with surface-combustion effect.

The real reason for the comparatively short flame (especially with our Eastern bituminous coals) from the bed of fuel operated by the underfeed principle is that the combustible gases liberated from the coal are subjected to a blowpipe action during their travel through the upper part of the fuel bed.

Owing to the separated positions of the retorts in the underfeed stoker, the greater part of the distilling-off of the volatile gases occurs only in isolated strips running from front to rear of the furnace and not evenly over the entire area of the fire bed.

Air is required to consume this gas rapidly, and in order to penetrate the part of the fuel bed found above the grate sur-

face and lying above the retorts, where the rapid gas distillation is taking place, the air is blasted into the fire bed through restricted openings or tuyères under more or less pressure; and it will be noted that these air openings, instead of being evenly distributed under the entire bed of fuel, are located in separated longitudinal lines, from front to back of the furnace, underlying only a small percentage of the grate area.

The quantity of air thus delivered is therefore very many times the volume needed to complete the combustion of the fuel located *directly* above the air openings (as the fuel lying over other portions of the grate area must also receive its needed air supply).

This projected air traveling at a considerable velocity is forced through the various cracks and interstices found in the compact fuel bed, which coal has been delivered into the furnace by the ramming action of the feeding plungers (or screws).

We next find this air mixing with the rising and very recently liberated gases, and both air and gases are hurled together against the heated masses of fuel (or coke) which intercept their paths of escape to the combustion chamber above.

Thus we have the blast of cool air meeting the combustible gases (heated in this case to a degree approximately their ignition temperature) and being projected with them against the highly heated baffle (or block) which acts with regenerative effect with just the same conditions and effect that we find in blowpipe practice in our shops or laboratories.

Such handling of the air and gas within the fuel bed tends to support a temperature within the burning mass which raises their mixture above the temperature of ignition of the gas, and this temperature is further maintained by the burning of the coke resulting from the coal after its gas has been distilled off.

The coke, which is, practically speaking, carbon, when raised to temperatures of from 1500 deg. to 1850 deg. fahr. would normally, under a quiescent state, burn to carbon monoxide, but with a large excess of air present which is made to sweep over its surface at high velocity, experiment has shown that carbon dioxide is produced.

These two actions of the gas and air within the fire bed have a tendency to complete the combustion of the combustible matter within the fuel mass, but only at such positions as the air and gas can find sufficiently free paths of passage to travel with sufficient velocity.

Owing to the compressed condition of the fuel bed, due to the ramming action of the feeding devices, the fire bed of the underfeed-stoker furnace is never open and spongy and of equal density over its entire surface, but it loosens up over the grate surface in lumps (especially with the caking coals) and opens in cracks and fissures, through which separated openings the air and newly generated gas are hurried at too high a velocity to produce a thoroughly even burning effect throughout any cross-section of the fuel bed.

It is due to the compactness of the fire bed and the small area of air-admission openings of the underfeed stoker that the (comparatively speaking) high air-blast pressures are required to force sufficient air into the furnace to complete the combustion of the entire fuel.

The underfeed method of stoking unquestionably produces a certain amount of gas combustion within its more or less deep fuel beds and this results in the production of a shorter flame above the fire surface, but does it always go far enough in this direction to eliminate all smoke?

At one time I was called upon to investigate a form of down-draft furnace which the inventor claimed embodied the principle of surface combustion, and I believe that he had a much better right to make such a claim than those trying to apply this theory to the action taking place in the fire beds of underfeed stokers, notwithstanding the fact that I could not wholly support the claim of the down-draft-furnace inventor.

The so-called *surface combustion* is produced by bringing a mixture of combustible gas with but slight excess of its required amount of air into intimate or penetrative contact with some solid body of a more or less porous, open, or granular structure heated to a high temperature, which form of solid body is known as a *catalyzer*. The tendency of the resulting chemical action (or catalytic action) taking place at the surface of these catalytic agents is to increase the velocity of the chemical combination, while the agents, in themselves, are left unchanged at the end of the reaction.

Every heated solid substance exerts some accelerating action on gaseous reactions, notably the metals of the platinum group in some of their subdivided forms, nickel, iron oxide, firebrick or other refractories, but it does not stand to reason that all other solids beside those named are equally effective catalyzers.

Reactions always occur most slowly in free-gas space, but there is the greatest difference in the catalytic activity of the various solids.

Catalytic action may take place on the surface of a lump of glowing coal during the time its occluded or liberated gases are given off by the action of the heat, but it does not follow that lumps of coal brought in contact with other surrounding gas act to very materially accelerate, in a similar manner, their reaction (necessary to effect the final product of combustion).

There are two ways in which the complete combustion of gases takes place. The first is a homogeneous combustion in which the velocity of the chemical change is dependent upon the order of the reaction, and combustion or reactions occur equally throughout the entire mass; in the second a heterogeneous combustion occurs in layers immediately in contact with a hot surface, and for this reason the term *surface combustion* has been given to this form of combustion.

But it must be noted that in order to obtain an effective surface combustion a refractory material is best adapted, and the activity of the surface presented is governed by the texture of the surface, the condition of the surface as related to the kind of gas consumed, and its retarding effect upon the films of gas formed.

Surface combustion is effected by forcing an explosive mixture of air and gas through refractory porous diaphragms, and in such cases the combustion seems to be concentrated within the interstices of the fireclay body, being always the most intense on the outer surface, where no flame is visible.

Surface combustion is also obtained by a somewhat less effective means by which the air and gas are forced through a porous bed of incandescent granular refractory material under pressure, and under favorable conditions the flame disappears and a high temperature results at the surface of the catalyzer.

With a proper understanding of what the term *surface combustion* is intended to convey, there can be but little reason for making a claim that the action in the fuel bed of an underfeed furnace is one of surface combustion.

In the underfeed furnace we find a great number of reverberatory actions taking place throughout the fuel bed, which rapidly raise the temperature of the air and gases; and by thus increasing their temperature we hasten the rate of combustion and this tends to produce a higher temperature, the same as is produced in ordinary blowpipe practice, where the flame is projected against a block having the ability to maintain a

high temperature; but it is not reasonable to call such an action one of surface combustion.

ALBERT A. CARY.

New York, N. Y.

Systematic Committee Work in Technical Societies

TO THE EDITOR:

Referring to the letter on systematic committee work in technical societies, submitted by Mr. Hess, I must take exception to Mr. Hess's strictures on the Research Committee. It is evident that he is imperfectly informed about the Committee's activity and methods, in undertaking a somewhat sweeping criticism. It is true that so far as actual research is concerned the Committee has, until last year, never been able to produce final results. No research can be handled without money. The Committee has been the means of getting some research work done, the results being published in papers. It is certainly very far from true that the Committee is not active. It is also not true that they have not asked for funds. I have upon several occasions applied to the Secretary for funds for the research work, but up to the present none have been allotted. The $300 mentioned by Mr. Hess is intended only for clerical work, and is entirely used up for that purpose.

The report of the Finance Committee to which Mr. Hess refers certainly shows some signs of life on the part of the Committee, so that at least it may be attested as something not quite ornamental. However, as regards the coördination of effort, I am in agreement with Mr. Hess, and the efforts of the Research Committee have been intended to aid in securing it. The writer has several times pointed out the need for eliminating duplicate committees in the various societies with a view to avoiding duplicate work; there should be some general plan adopted for correlating the work of all societies. The latest movement for the accomplishment of this end has been by way of the National Academy of Sciences, but there appears to be no more difficult task than trying to get people together on the subject of research. We have many different research bodies in this country, all more or less endowed, employed upon scattering research. These would produce their results much more efficiently if they were correlated so that no overlapping work was undertaken. It would appear to be the duty of the new secretary of the National Research Council to be the center through whom all of these various research activities would be cleared. I agree with Mr. Hess that the absence of funds is a handicap in getting results, but it is not at all impossible to obtain funds.

With regard to the suggested plan of Mr. Hess, perhaps he is not aware that the Research Committee is already working along these lines, except that the sub-committees have as yet never had any funds allotted to them, but have procured what funds they could from outside sources. There is all the more credit due, I think, in this case to those sub-committees that have accomplished definite results.

R. J. S. PIGOTT,

Bridgeport, Conn. *Chairman Research Committee.*

WORK OF THE BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in The Journal, in order that anyone interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee as approved by the Council on February 16, 1917, in Cases Nos. 76, 116, and 124 to 135 inclusive. In this report, as previously, the names of inquirers have been omitted.

CASE NO. 76 (Reopened)

Inquiry: What net area should be considered in calculating staybolts with tell-tale holes drilled in their ends? Also an opinion is requested whether in determining the load on a bolt, the full pitch dimensions of the area stayed should be used, or whether the area occupied by the bolt itself should be deducted.

Reply: The question as to the area of a drilled staybolt is answered by Par. 220, which specifies clearly the net cross sectional area of the stay. The full pitch dimensions of the stays should be employed in determining the total area and the area occupied by the bolt itself may be deducted to determine the net area to be supported by the stays and the load carried by the stays.

CASE NO. 116

Inquiry: In the case of safety valves does the second sentence of Par. 286 require the raised face specified as a detail in Tables 15 and 16 of the Appendix? Would it not be better practice to make the boiler flanges of all safety valves flat-faced?

Reply: It is the opinion of the Committee that flanged cast iron pipe fittings used for boiler parts, for pressures up to and including 160 lb. per sq. in. shall conform to the American Standards given in Tables 15 and 16 of the Appendix, except that the face of the flange of a safety valve as well as that of a safety valve nozzle, shall be flat and without the raised face. The face of the flange of a safety valve, as well as that of a safety valve nozzle, shall have a flat face for pressures up to and including 250 lb. per sq. in. and shall have a raised face at higher pressures.

CASE NO. 124

Inquiry: a Where reinforcing of heads is provided for as in locomotive type boilers, the heads being braced by separate plates, what material may be used for this reinforcing plate, as well as also for the gusset plates?

b Does Par. 269 allow the use of two safety valves whose combined area is equal to the 3-in. valve?

c Is it allowable under Pars. 182 and 183 to insert a row of staybolts through the center of a joint, the spacing to be the same as the outer row of rivets in the joint?

Reply: *a* It is the opinion of the Committee that this question is answered by Pars. 2 and 5 of the Boiler Code, flange steel being acceptable where not exposed to the fire or products of combustion.

b The intent of Par. 269 will be expressed by adding the following words to the paragraph: "In which case one or more safety valves may be used."

c A row of staybolts is allowable through the center of a joint provided the requirements in the Code as to back pitch of rivets and dimensions of ligaments are met, by considering a staybolt or other hole in the same way as a rivet hole. Where the plates at the two ends of a stay are of different thicknesses, the pitch must be that corresponding to the thinnest plate.

CASE NO. 125

Inquiry: Is the method of fastening the crown sheet of the boiler shown in Fig. 6 by using staybolts that pass through

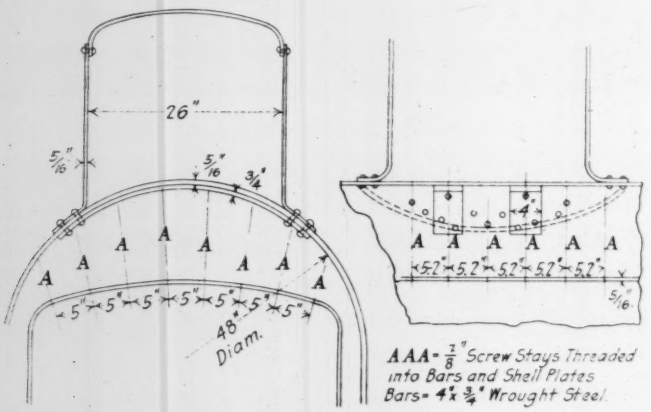


FIG. 6 PROPOSED METHOD OF REINFORCING NEUTRAL SHEET UNDER DOME FOR SUPPORT OF CROWN SHEET

the reinforced neutral sheet underneath the dome strong enough to withstand 100 lb. working pressure?

Reply: The construction illustrated is unusual and is not directly covered in the Boiler Code. The stresses in the reinforcing bars which come beneath the dome are similar to those which exist in crown bars and the required section of the bars may be computed by the rules given in Par. 230 of the Code.

CASE NO. 126 (Annulled)

CASE NO. 127

Inquiry: An interpretation is requested of Pars. 323, 324, and 325 in their application to different types of boilers. If Par. 325 is to be used in conjunction with Pars. 323 and 324 and refers to return tubular boilers only, should this not be so stated?

Reply: It is the opinion of the Committee that Par. 325 refers to any type of boiler.

CASE NO. 128

Inquiry: An explanation is desired of the conflict that appears to exist between Pars. 12 and 268 of the Boiler Code in their application to the use of cast iron nozzles for boilers.

Reply: It is the intent of the rules in the Boiler Code not to allow the use of cast iron nozzles riveted to the shell of a steam boiler for any temperature or pressure.

CASE NO. 129

Inquiry: In view of the difficulty at the present time of securing iron boiler tubes to meet the Code specifications, permission is requested to use wrought iron tubes which on account of their small diameter, cannot meet the flanging test.

Reply: The requirements of the flanging test for wrought iron tubes will be changed in the forthcoming revision of the Code. They will be so modified as to make it possible for acceptable wrought iron tubes of small diameter to meet them.

CASE NO. 130

Inquiry: A ruling is requested covering the staying of crown sheets of furnaces of locomotive type boilers by means of a special form of arch bars which are attached to the crown sheet by stays spaced at regular intervals.

Reply: There are no rules in the Boiler Code for arch bars of the special type referred to. There are rules given in Par. 230 for straight crown bars and girder stays which would have to be modified in order to apply them to these special arch bars.

Where furnaces require staying Par. 212 of the Code specifies that they shall be stayed as flat surfaces. The rule for staying as flat surfaces is given in Par. 199 and the maximum pitch of staybolts at different working pressures and for different thicknesses of plate is given in Table 3. These rules and the values in the table would apply in the case of the stays used between the top of the furnace and the arch bars, the pitch to be used being the maximum, measured either between the rows of stays in the arch bars or between the stays in a given arch bar. By applying the rules for stays the allowable working pressure can be determined if the crown bars are made strong enough and are properly supported at their ends.

CASE NO. 131

Inquiry: Will a 1½-in. brass body safety valve be acceptable on the outlet from a superheater provided it conforms to all other requirements of the Boiler Code?

Reply: It is the opinion of the Committee that under Par. 289 the use of brass body safety valves is not permissible with superheated steam.

CASE NO. 132

Inquiry: Is Par. 321 intended to apply to the fittings on water columns as well as to the pipe connections? In other words can extra heavy cast iron crosses be used for the fittings instead of brass crosses?

Reply: It is the opinion of the Committee that Par. 321 applies to the fittings as well as the pipe connections. Therefore cast iron crosses or other fittings will not be permissible.

CASE NO. 133 (Annulled)

CASE NO. 134 (Annulled)

CASE NO. 135

Inquiry: Is it permissible to make use of patch bolts instead of rivets in fastening the flanged edges of the sheets in a door hole of a locomotive type boiler, where accessibility to the work for riveting is impossible?

Reply: Where there is insufficient room to use rivets such as in the specific case mentioned the Boiler Code does not prohibit the use of patch bolts.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

THE most far-reaching step, not only recently but in the progress of the engineering profession, has been taken during the past month. Upon a foundation laid by others, President Hollis, with characteristic energy, has actually accomplished the preliminary work toward the organization of a clearing house for the engineering profession, whereby questions of general interest may be properly considered and a means provided for united action upon matters of concern common to engineers and the public. All societies, participating by representatives, like the states in our Union, preserve in all respects their prerogatives, entities and freedom for individual action. This organization is to be known as the Engineering Council. It will be a department of the United Engineering Society and participated in by not only the Founder Societies of the United Engineering Society but all the other leading societies.

Each of the societies will be represented by one or more delegates according to its size and, unless objection is made by some of the member societies, the Council shall speak for the societies collectively on public questions. When there is objection the matter shall be referred to the governing bodies of the societies whose representatives protested.

The Council will meet in various places and in this way establish a national atmosphere, and in every way develop a representative but nevertheless democratic organization.

In the past month Dr. Hollis has also secured the coöperation of the other societies in a joint telegram to the President of the United States, as follows:

To the President,
Executive Mansion, Washington, D. C.

We, the presidents of the National Societies of Civil, Mining, Mechanical, and Electrical Engineers, and of United Engineering Society, with a membership of thirty thousand, cordially unite in supporting Congress and the Administration in the stand for freedom and safety on the seas, and we are confident that we represent the membership of the four societies in offering to assist toward the organization of engineers for service to our country in case of war.

(Signed) GEORGE H. PEGRAM, President,
American Society of Civil Engineers.
L. D. RICKETTS, President,
American Institute of Mining Engineers.
IRA N. HOLLIS, President,
American Society of Mechanical Engineers.
H. W. BUCK, President,
American Institute of Electrical Engineers.
CHARLES F. RAND, President,
United Engineering Society.

The President of our Society and myself have received a number of communications and oral inquiries in regard to enrollment in an officers' reserve corps, and it is the expectation within the near future to take up comprehensively the whole subject and to prepare a digest of all the acts of Congress and authorizations pertaining to this matter both for the Army and for the Navy, and to instruct the membership in general terms as to how engineers may secure assignment to positions for which they are especially fitted.

CALVIN W. RICE, *Secretary.*

THE SPRING MEETING AT CINCINNATI

PLANS for the Spring Meeting of The American Society of Mechanical Engineers, the semi-annual general meeting of the Society, to be held in Cincinnati, Ohio, May 21 to 24, are sufficiently under way to enable the following announcements regarding the professional and social events of the meeting to be made.

There will be a Joint Session with the Machine Tool Builders' Association, as previously announced in The Journal. A session has been planned by the Sub-Committee on Gas Power on the subject of High-Speed Gasoline Engines. Recent developments in connection with high-speed engines for automobile and aviation service, based on a clearer understanding of the processes of combustion and the mechanical problems involved, have led to increase of mean effective pressure and improvement in combustion-chamber design, valve arrangements, balancing, and the use of aluminum alloys, etc.

There will be a Machine-Shop Session in charge of the Sub-Committee on Machine Shop Practice, at which will be discussed questions relating to the design and construction of machine tools, and other problems of interest, particularly to those engineers connected with the machine-tool industry.

A session on some of the economic principles involved in the manufacture of munitions, such as questions relating to financing, specifications, inspection, design of parts for quantity manufacture, principles of organization which have been found successful, etc., will also be held.

The proposed entertainment features include an informal gathering on the first evening, with addresses of welcome, followed by dancing.

On Tuesday morning there will be a trolley ride to Fort Thomas, a beautiful site overlooking the Ohio River, and of particular interest at this time. During the afternoon the ladies will be invited to visit Rookwood Pottery and the Art Museum. For the evening there is planned a symphony concert or a dinner followed by dancing at the Zoo.

On Wednesday morning a trip will be arranged for the ladies through the leading stores of Cincinnati, some of which are very handsome, and a trip through one of the city's skyscrapers in order to get a view of the city and the Ohio Valley. On Wednesday afternoon a trip will be ar-

ranged to the Zoo in special cars; this is a very beautiful place in May and one of great interest.

On Thursday morning a special ladies' program, the details of which have not yet been arranged, will be given. In the afternoon a motor-car ride is planned to prominent places in Cincinnati, including Mt. Storm Park, University of Cincinnati, Observatory, and Ault Park.

On Friday morning trips will be arranged at additional expense to members to such places as Fort Ancient, Mammoth Cave, in Kentucky, and Lexington, Kentucky. It is believed that cards can be provided for all guests to one of the golf clubs here.

The Society has already held two general meetings at Cincinnati, one in May 1890 and the other in May 1900.

Nothing can furnish a more potent testimony of the growth of the Society than a reperusal of the minutes of the 1890 Cincinnati Meeting. In it we find that "the Council has made arrangements by which the Society will enter upon the occupancy of part of the house No. 12 West Thirty-first Street, New York City." The seating capacity of the auditorium is given as "over two hundred," the top floor and basement were leased to other parties to meet the financial burden imposed during the first year of occupancy of the House. The American Institute of Electrical Engineers were also tenants, etc. Comparison with present facilities of the Society in the Engineering Societies' Building—and the present accommodation is becoming increasingly inadequate—affords sufficient evidence that each of the twenty-six years passed has contributed its share to the general and unmistakable progress of the Society and ipso facto of the Engineer.

The 1890 Cincinnati Meeting is memorable for the report of a "Special Committee appointed by the Council to memorialize the Congress of the United States in the matter of a suitable recognition by the Nation of the work of Capt. John Ericsson, late member of this Society." It will perhaps be recalled that in The Journal for May 1916 are reported the speeches of members representing the Society at the Hearing of the Bill before Congress for the erection of a monument to the memory of Ericsson, which, it is to be hoped, will lead to the speedy consummation of the projected memorial.

The 1900 Cincinnati Meeting was also a memorable one, for on that occasion was read the first paper on motor vehicles, "The Automobile Wagon for Heavy Duty," by Arthur Herschmann. "I believe," said the author in his conclusion, "that if the motor wagon is given an unobstructed field and fair play, it will hold its own and oust the horse-drawn truck in short order. The change must come, and with perhaps the exception of the harness maker, everybody will benefit by it." The investigations described in that paper were made in the interest of the Adams Express Co., and, judging by their ubiquitous delivery wagons alone, have borne ample fruit.

We have every reason therefore to look forward to the third Cincinnati Meeting, and do not doubt that it will be instrumental in furthering the general interests of the Society and the profession.

Cincinnati is a convenient city for conventions, being within a night's ride of the principal cities of the central states and many southern and eastern cities; also within twenty hours of the Atlantic seaboard and the western prairies. It is the terminal for 200,000 miles of first-class railways; to the east there are six trunk lines, the Big Four Division of the New York Central, connecting New York and Boston, the Erie and Pennsylvania from New York, Baltimore and Ohio from New York and Baltimore, Chesapeake and Ohio from New York and Newport News, and the Norfolk and Western from Norfolk, Va. From the west come the trunk lines of the Big Four, and Baltimore and Ohio.

The city has a great many points of interest. There is the Rookwood Pottery, located on the brow of Mt. Adams, overlooking the downtown section of the city. Here the beautiful Rookwood ware is produced; every piece is a separate and distinct creation of the artist and is given a finish by a secret process which has never been successfully imitated. Nothing is more interesting than to watch the potter take a piece of wet clay and before the eyes of the visitor make it into a vase which, after it has been burned in the great furnaces for many days, receives a finishing touch causing it to become a thing of great beauty and high value.

Then there is the Fernbank Dam in the Ohio River at the western city limits, said to be the largest movable dam in the world. It is one of the series of fifty-four locks and dams being built by the United States Government in the Ohio River, at a cost of about sixty million dollars, to make it navigable, with a depth of not less than nine feet, all the way from Pittsburgh to the river's mouth at Cairo.

The Cincinnati University in Burnet Woods comprises McMicken, Cunningham, and Hanna Halls, the Van Wormer Library, Engineering Hall, Chemistry Building, Gymnasium, Power Plant and Observatory, which latter is on Mount Lookout, six miles from the center of the city. It is the only municipal university in the United States. The entire group of buildings cost nearly $2,000,000. The Ohio Mechanics' Institute is another great educational institution. It is now housed in a magnificent new structure at Walnut, Canal and Clay Streets, which accommodates 4000 students, and is a big factor among scientific and industrial training schools. Cincinnati has a city hall which cost $2,000,000, and three new high schools which in architecture and appointments are not excelled in any city in the United States. The government building and custom house on Fifth Avenue cost over $6,000,000. A new municipal hospital cost $4,000,000.

Other points meriting the attention of the visitor are: the water-tower, a stone structure 120 ft. high, surrounded by a beautiful residence district; from the Fort may be had what is said to be the finest river view in the United States. The Tyler Davidson Fountain, given to the city by Henry Probasco as a memorial to Tyler Davidson, a public-spirited citizen of the old days in Cincinnati (this was cast at the Royal Bronze Foundry in Bavaria and is made of old cannon from numerous battlefields of Europe); the Old St. Peter's Cathedral; the hall where Robert G. Ingersoll made his famous "plumed knight" speech in nominating James G. Blaine for President; the inclined planes which lift cars from the downtown levels to the top of the surrounding hills; and the Music Hall on Elm Street, opposite Washington Park.

Cincinnati has a system of public parks and boulevards which covers about 2500 acres, and is now undergoing extensions and improvements. The oldest is Eden Park, located on the crest of Mt. Adams. It was once the vineyard of Nicholas Longworth, great-grandfather of Congressman Longworth. When the late King Edward VII of England visited Cincinnati, while Prince of Wales, he pronounced Eden Park the most beautiful natural park of any he had seen in his travels. Others have testified to the beauty of this park and especially to the splendor of the river scenery. Other beautiful parks in Cincinnati are Burnet Woods, in which is located the University of Cincinnati; Lincoln Park and Washington Park, the latter being located in the downtown district, where thousands tarry for a few minutes each bright day.

Members attending this meeting will have an opportunity of making tours in various directions, besides the parties already arranged, as stated at the beginning. Among the points most easily reached from Cincinnati may be mentioned: Chattanooga, Tenn., where the battlefields of Lookout Mountain, Signal Mountain and Missionary Ridge offer sentiment, history and beauty; Boonesborough, Ky., which is the oldest settlement established by English-speaking people in the Mississippi Valley, and which lies on the west bank of Kentucky River, about 150 miles from Cincinnati. Lincoln's birthplace, near Hodgenville, Ky., is another place of historical interest in Kentucky, easily reached from Cincinnati; Mammoth Cave and Colossal Cavern are 200 miles distant from Cincinnati, being about eight miles from Glasgow Junction, Ky.; the tomb of President Harrison is situated at North Bend, fifteen miles from Cincinnati; Point Pleasant, Ohio, the home and birthplace of Ulysses S. Grant, is only about twenty miles from Cincinnati, while Georgetown, where the great General spent his boyhood, is but forty miles distant.

Cincinnati has quite a German element in its population and its view of life has been much influenced by the German idea of hard work when work is on the program and wholesome recreation when there is time to play. Back of it all there is a people whose hospitality has always been of the most open-hearted kind, a people ready to give the Society a hearty welcome at its forthcoming meeting there.

Nominations for Officers of the Am.Soc.M.E.

FOR ELECTION IN DECEMBER 1917

The Constitution of the Society in C 47 provides among the Annual Committees:

"A Nominating Committee appointed by the President."

It further provides in C 48

A "Special Nominating Committee: Twenty or more persons entitled to vote may constitute themselves a Special Nominating Committee, with the same powers as the Annual Nominating Committee."

The procedure in the nominations for office is provided in the following By-Laws:

B-27 A Nominating Committee of five members, not members of the Council, shall be appointed before February first of each year by the President. The Secretary shall publish the names of this Committee in the March issue of The Journal together with a request to the voting membership of the Society that they recommend to the Committee the names of eligible persons for the elective offices to be filled at the next election. This Committee shall deliver to the Secretary in writing between the first and the fifteenth of June the names of its nominees for the various effective offices next falling vacant under the Constitution, together with the written consent of each nominee. The names of the nominees for the various offices proposed by this Committee shall be published by the Secretary under the names of the Committee in the July issue of The Journal.

B-28 A special Nominating Committee, if organized, shall on or before October fifteenth, present to the Secretary the names of its nominees for the elective offices next falling vacant under the Constitution, together with the written consent of each nominee. The names of the nominees for the various offices proposed by this Committee shall be published by the Secretary under the names of this Committee in the November issue of The Journal.

There are to be elected in December next

A President to hold office for one year
Three Vice-Presidents to hold office for two years
Three Managers to hold office for three years
A Treasurer to hold office for one year

The President, Ira N. Hollis, has appointed the following Nominating Committee for these officers:

Willis H. Carrier, of Buffalo
Fredk. W. Gay, of San Francisco
A. M. Lockett, of New Orleans
Paul B. Morgan, of Worcester
Louis E. Strothman, of Milwaukee

These names were selected by the following Sections, grouped geographically, and accepted by the President:

GROUP 1 San Francisco and Los Angeles
GROUP 2 Atlanta, Birmingham, Cincinnati, New Orleans and St. Louis
GROUP 3 Chicago, Detroit, Indianapolis, Milwaukee and Minnesota
GROUP 4 Boston, New Haven and Worcester
GROUP 5 Baltimore, Buffalo, Erie, New York and Philadelphia

This Nominating Committee is to meet at the Spring Meeting of the Society in Cincinnati, Ohio, May 21-24, and would be pleased to receive suggestions from the membership.

Under the terms of By-Laws B-27 and B-28 the voting membership are requested to send the Nominating Committee or Committees, in care of the Secretary, 29 West 39th Street, New York, N. Y., their recommendations of names for any or all of the elective offices to be filled at the next election.

These recommendations should be sent in early and not later than June 1st.

Sir William H. White Memorial

It will be remembered that shortly after the death of Sir William White, on Feb. 27, 1913, a movement was initiated to establish a suitable memorial in his honor.

The members of many engineering and scientific societies of several nations were given an opportunity to subscribe and a committee of notable engineers was formed in England to take charge of the movement.

A considerable number of the members of The American Society of Mechanical Engineers responded to the invitation and a goodly sum was sent to the committee in the name of our Society, of which Sir William was an Honorary Member.

The work has been consummated and the Committee has made its final report.

The memorial funds, resulting from private subscription, amounted to over $16,000.

The memorial has taken three forms:

1 The "Sir William White Research Scholarship in Naval Architecture," which is to be administered by the Council of the Institution of Naval Architects with a fund of nearly $14,000.
2 A donation to Westminster Hospital of $500.
3 A portrait panel in marble of Sir William erected in the Entrance Hall of the Institution of Civil Engineers in London, in which about $1500 is invested.

A reproduction of this latter memorial is shown in this number of The Journal.

A larger reproduction will be suitably inscribed and framed and placed on the wall of the Society's home.

Thus has been accomplished the desire of many engineers of many nations to do honor to an engineer of great distinction and a man of most lovely character.

The Committee of the Am.Soc.M.E. was Jesse M. Smith, *chairman;* Alexander C. Humphreys, Frederick R. Hutton.

The Americanization Movement

The Chamber of Commerce of the United States, whose Immigration Committee is displaying special activities in the direction of absorbing foreign elements into our national stock, is to be congratulated on its recent efforts to enlist the coöperation of the engineering profession in the furtherance of Americanization. A dinner was given on January 19, followed by a discussion on The Engineer in Americanization, in which quite a number of speakers took part.

Sr WILLIAM HENRY WHITE K.C.B. LL.D. D.Sc. F.R.S.
PRESIDENT 1903-4
DIRECTOR OF NAVAL CONSTRUCTION 1885-1902
A TRIBUTE FROM THE SHIPBUILDERS
AND ENGINEERS OF MANY NATIONS

PORTRAIT PANEL OF SIR WILLIAM HENRY WHITE

Dr. Hollis, President Am.Soc.M.E., touching on the question under discussion, said that the underlying aspect of the European War related to the attitude of the individual toward government; whether he believed in the government and heart and soul obeyed the orders of a government, or whether the government was a mere machine through which the individual was permitted to develop as high as possible in the service of mankind. He could not help feel that this was the most important side of preparedness in this country, and that too much emphasis had been put on *military* at the expense of *service* to our nation. He had never believed that the foreigners in this country, Russian, German, English, French or any other, were against America, nor that we have any German population opposed to American institutions.

He favored some definite constructive suggestion rather than discussion, and thought the best thing to do with regard to foreigners coming to America was to organize for after-work education and scholarships, and a general education, especially in American institutions. In conclusion he said he felt very strongly that the Engineer would back up anything the Chamber of Commerce might propose towards the betterment of citizenship in America and of Americanization.

Mr. Howard E. Coffin spoke on the constitution of the Committee on Industrial Preparedness, and the work it had already accomplished in connection with the industrial inventory of the country, the data of which will form the basis of the whole structure toward our national military and naval defence.

With regard to Americanization, he favored employment cards in every employment agency, which would give particulars as to naturalization, when first papers were taken out, etc., followed in due course by a definite declaration that no employee will be raised to a position of responsibility or trust unless he is an American citizen.

Transactions Errata

From time to time the attention of the Society has been called to slight errata in the volumes of Transactions, and these errata have been kept on file and will be compiled and published at an early date.

Mr. F. W. Dean furnishes the following corrected Table 1 of his paper on Damages for Loss of Water Power, which was presented at the December, 1915, meeting of the Society and published in Volume 36 of the Transactions:

TABLE 1—GENERAL COSTS OF POWER BY STEAM AND WATER

Annual Costs of Power by a Steam Plant.	Annual Costs of Power by Water Combined with Steam Sufficient for a Uniform Power	
	Water Power Plant	Auxiliary Steam Plant
Interest	Interest	Interest
Depreciation	Depreciation	Depreciation
Repairs	Repairs	Repairs
Insurance	Insurance	Insurance
Taxes	Taxes	Taxes
Attendance	Attendance	Attendance
Fuel	.....	Fuel
Supplies	Supplies	Supplies

Naval Consulting Board

A special meeting of the Naval Consulting Board of the United States, called at the request of Secretary of the Navy Daniels, was recently held in the Engineering Societies Building for the purpose of considering certain matters which are vital to the proper defense of the United States in the event of war.

William L. Saunders, vice-chairman of the board, presided, and some of the matters discussed were the production and organization of the industries whose outputs would be national necessities in the event of war, aeronautics, transportation,

submarines, mines and torpedoes, and ordnance and explosives.

Among those at the meeting were Bion J. Arnold, Frank J. Sprague, Peter Cooper Hewitt, Howard E. Coffin, Hudson Maxim, Elmer A. Sperry, and Lawrence Addicks, who are members of the board, and Rear Admiral G. E. Burd, Industrial Manager of the New York Navy Yard; Captain W. S. Smith, U. S. N., representing the Navy Department in Washington, and Lieutenant Commander Charles S. McWhorter, one of the submarine experts of the service.

It was voted to notify the Secretary of the Navy that the "board holds itself at the service of the Department of War or of the National Council of Defense, to act as a board of inventions, or in any other capacity which may be of use to the Government in the present emergency."

The board adjourned to meet at the call of the President, who is Thomas A. Edison, who was reëlected. William L. Saunders, Peter Cooper Hewitt, and Thomas Robbins were the other executive officers elected.

Ericsson Monument

The advisory committee, to be known as the John Ericsson Monument Commission, appointed by the United States Government to handle certain details with regard to the erection and unveiling of the monument to Captain John Ericsson at Washington, includes the following members of The American Society of Mechanical Engineers: John E. Ericsson, Chicago, Ill.; John G. Bergquist, Glenhead, L. I.; F. O. Hoagland, Hartford, Conn.; C. von Philp, Bethlehem, Pa.; Erik Oberg, New York City.

The commission will meet in the spring in Chicago.

CANDIDATES FOR MEMBERSHIP

TO BE VOTED ON AFTER APRIL 10, 1917

THE American Society of Mechanical Engineers is an organization for mutual service of over 7700 engineers and associates cooperating with engineers. The membership of the Society comprises Honorary Members, Members, Associates, Associate-Members and Juniors, all elected by ballot of the Council. Application for membership is made on a regular form furnished by the Secretary which provides for a statement of the standing and professional experience of the applicant and requires references from voting members personally acquainted with the applicant. The requirements for admission to the various grades will be furnished upon request.

Below is the list of candidates who have filed applications for membership since the date of the last issue of The Journal. These are classified according to the grades for which their ages qualify, and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third class under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to scrutinize this list with care and advise the Secretary promptly of any objections to the candidates posted. All correspondence in this regard is strictly confidential. Unless objection is made to any of the candidates by April 10, 1917, and providing satisfactory replies have been received from the required number of references, they will be balloted upon by the Council. Those elected will be notified about May 20.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Alabama

GABOURY, JOHN D., Superintendent of Power,
Woodward Iron Co., Woodward

LANDGREBE, KARL L., Assistant General Superintendent,
Tenn. Coal, Iron & R. R. Co., Ensley

LIND, EDWARD W., Draftsman,
Tenn. Coal, Iron & R. R. Co., Fairfield

LOWE, JAMES R., Vice-Pres.,
McCleary Jemison Mchy. Co., Ensley

MAHONEY, JOHN C., Turbine Engineer,
Atlanta Dist., General Electric Co., Atlanta

MOFFETT, CHARLES A., Vice-President,
Gulf States Steel Co., Birmingham

TAYLOR, FLEMEN C., General Gas Foreman,
Tenn. Coal, Iron & R. R. Co., Ensley

WILCOX WILLIAM F., Superintendent Water Supply,
Tenn. Coal, Iron & R. R. Co., Ensley

California

ALLEN, ARTHUR P., Chief Draftsman, Engineering Department,
Union Iron Works Co., San Francisco

BENNETT, FREDERICK, formerly manager of Mchy. Dept.,
Parrott & Co., San Francisco

DEMAREST, D. C., Manager,
Angels Iron Works, Angels Camp

FIELD, ROBERT N., Mechanical Engineer,
Mammoth Copper Mining Co., Kennett

KIBELE, O. B., General Superintendent Transportation,
Union Co., Los Angeles

SCHARPENBERG, CHARLES C., Efficiency Engineer,
Standard Oil Co., Bakersfield

STODDARD, CHARLES H., Engineer,
Moore & Scott Iron Works, San Francisco

Colorado

CARSON, LOUIS T., Assistant Chief Engineer,
Great Western Sugar Co., Denver

DEWEY, LOUIS C., Mechanical Engineer,
Jackson Compressor Co., Denver

JONES, ARTHUR L., District Engineer,
General Electric Co., Denver

Connecticut

ABBOTT, ROY J., Section Leader,
Pratt & Whitney Co., Hartford

ALLGRUNN, FREDERICK S., Mechanical Engineer,
Remington Arms & Ammunition Co., Bridgeport

FRAY, GEORGE H., Assistant to Mechanical Engineer,
Bridgeport Brass Co., Bridgeport

GORDON, WILLIAM A., General Superintendent,
Birmingham Iron Fdy., Derby

HULME, PERCY A., Assistant Superintendent,
New Britain Mch. Co., New Britain

JOHNSON, EUGENE A., Equipment Engineer,
Remington Arms-Union Metallic Cartridge Co., Bridgeport

LATTIN, ALBERT N., Mechanical Superintendent,
New Departure Mfg. Co., Bristol

LOOMER, LEWIS L., Testing and Investigating Engineer,
American Brass Co., Waterbury

MCGRATH, WILLIAM C., Superintendent,
Stamford Rolling Mills Co., Springdale

MUNSON, JOHN G., Construction Engineer,
J. G. White Engineering Corp., New Haven

OTTERSON, JOHN E., Vice-President,
Winchester Repeating Arms Co., New Haven

PICKLES, JOHN F.,
With W. F. Pickles, Manufacturing Automatic Drying Regulator for Paper Making Machines, Buckland

RODNEY, KEITH R., Engineering,
Bullard Machine Tool Co., Bridgeport

ROMER, ALBERT J., Sales Engineer,
The New Departure Mfg. Co., Bristol
SIMPSON, GEORGE P., Superintendent,
Oven Equipment & Mfg. Co., New Haven
UNGER, G. A., Technical Manager and Chief Engineer,
S. K. F. Ball Bearing Co., Hartford
WILLIAMS, CHARLES E., General Manager,
William L. Gilbert Clock Co., Winsted

Delaware

BRENTLINGER, JOHN M., Operative Engineering Div., Engineering Department,
E. I. du Pont de Nemours & Co., Wilmington
DERR, RALPH, Engineer, Mech. Experimental Div.,
E. I. du Pont de Nemours & Co., Wilmington
FOSTER, WILLIAM B., Assistant Chief Engineer,
E. I. duPont de Nemours & Co., Wilmington
MEREDITH, HARRY P., Master Mech., Maryland & Delaware Div.,
Baltimore & Washington R. R., Wilmington
SCHULZ, LOU E., Construction Engineer,
E. I. du Pont de Nemours & Co., Wilmington
SELLERS, WILLIAM F., President,
Edge Moor Iron Co., Edge Moor
STONE, ROY L., Operative Engineer,
E. I. du Pont de Nemours & Co., Wilmington
WARNER, JACOB L., Assistant Engineer,
E. I. du Pont de Nemours & Co., Wilmington

District of Columbia

JOHNSON, ELMER, Assistant Mechanical Engineer,
U. S. Office of Public Roads & Rural Engrg. Washington
SMITH, THOMAS W., Mechanical Engineer, Transportation Div.,
Quartermaster Corps, U. S. Army. Washington

Georgia

GREAGAN, JOHN J., Sales Engineer,
Allis-Chalmers Mfg. Co., of Wis., Atlanta

Illinois

AKERS, AXEL, Engineer in Charge Mech. Section,
Department of Public Works, Bureau of Engineering, Chicago
ALLAN, CHARLES D., Consulting Engineer, Chicago
BABCOCK, FRED R., Proprietor,
Electrical & Power Equipment Co., Chicago
CROSBY, WILLIAM F., Service Manager,
International Motor Co., Chicago
HANNIFIN, A. V., Treasurer and Works Engineer,
Hannifin Mfg. Co., Chicago
HENLEY, ROY A., General Superintendent,
The American Cement Plaster Co., Chicago
HENNING, CHARLES F., Manager,
Gypsum Fireproofing Co., Chicago
KYLE, SAMUEL C., Consulting Engineer,
Engineering & Sales Corp., Chicago
MONTAGUE, EDWARD, Superintendent,
Amalgamated Mchy. Corp., Chicago
SEIDLE, NORMAN R., Manager Plate Construction Dept.,
Joseph T. Ryerson & Son, Chicago
WILDER, THOMAS E., President,
Wilder & Co., Chicago
WILSON, GEORGE L., Counsel Service,
Efficiency Engineering Lines, Chicago

Indiana

EVANS, BERNARD C., Die Designing,
General Electric Co., Fort Wayne
HAYDON, GEORGE F., Chief Engineer,
Prudential Casualty Co., Indianapolis
WILLIAMS, LEWIS M., Sales Engineer,
Fort Wayne Oil & Supply Co., Fort Wayne

Kentucky

TREFZ, JULIUS J., General Superintendent,
The Anglo-American Mill Co., Owensboro

Louisiana

ANDERSON, JAMES, JR., Superintendent, Pipe Line Dept.,
Standard Oil Co. of La., Shreveport
SPENCER, ORRIE G., Chief and Consulting Engineer,
Lyon Lumber Co., Garyville

Maine

GOLDSMITH, WILLIAM H., JR., Chief Draftsman,
Biddeford Plant, Saco-Lowell Shops, Biddeford
SAWYER, HARRY B., Treasurer,
The Kelley Spear Co., Bath

Maryland

BRIDGES, JOHN S., President and General Manager,
Coale Muffler & Safety Valve Co., Baltimore
SCHMEISSER, ERNEST G., Secretary and Treasurer,
Baltimore Oil Engine Co., Baltimore
WYGODSKY, LEON, Vice-President and General Manager,
Baltimore Oil Engine Co., Baltimore

Massachusetts

CURRY, MALCOLM, General Engineer,
American Thread Co., Holyoke
LOFTUS, JAMES J., Sales Engineer,
Reed-Prentice Co., Worcester
MACKAY, SIMON, Works Manager,
The L. S. Starrett Co., Athol
NEWTON, ALBERT E.,
With Reed-Prentice Co., Worcester
NORTH, FRED K., Superintendent,
American Steam Gauge & Valve Mfg. Co., Boston
ROBINSON, CHARLES A., Mechanical Superintendent,
Merrimack Mfg. Co., Lowell
SOPER, CLEVELAND C., Instructor Machine Drawing and Design,
Wentworth Institute, Boston
TENNEY, Arthur A., Purchasing Agent,
Fitchburg Steam Engine Co., Fitchburg
WARREN, RALPH L., General Manager,
Warren Brothers Co., Boston
WIDDERBERG, OSCAR A., Machine and Mill Designer,
American Steel & Wire Co., Worcester

Michigan

DE VISSER, JOHN H., Treasurer,
The Coon-De Visser Co., Detroit
HEAVENRICH, OSMOND D., Chief Engineer,
Detroit Pressed Steel Co., Detroit
KNUDSON, WILLIAM S., Mechanical Engineer,
Ford Motor Co., Detroit
PARKS, BURRITT A., Consulting Engineer,
Byron E. Parks & Son, Grand Rapids
RIX, MILTON H., General Superintendent,
Sheffield Car Co., Three Rivers
TOWER, GLENN L., Mechanical Engineering,
With The Detroit Edison Co., Detroit

Minnesota

LILYGREEN, FRANK G., General Shop Superintendent,
American Hoist & Derrick Co., St. Paul
MOYER, MALCOLM B., President,
Moyer Manufacturing Co., Montevideo

Missouri

ROSENOW, HENRY F., Chief Engineer Power Plants,
Brown Shoe Co., St. Louis
STOLBERG, EMIL C., Assistant Engineer, Improvement Dept.,
American Car & Foundry Co., St. Louis

Nebraska

SOUTH, JOHN H., Superintendent,
Nebraska Culvert & Mfg. Co., Wahoo

New Jersey

CARNEY, EDWARD B., Mechanical Engineer,
Safety Insulated Wire & Cable Co., Bayonne
CAVE, HENRY, Director Technical Research,
Davis-Bournonville Co., Jersey City
HANNUM, JOHN P., Mechanical Assistant Superintendent,
E. I. du Pont de Nemours & Co. Carney's Point
LOVEKIN, LUTHER D., Engineer,
New York Shipbuilding Co., Camden
ROUSE, RICHARD, JR., Manager Manufacturing Dept.,
Boynton Furnace Co., Jersey City
VAIL, THOMAS C., Superintendent,
Spicer Mfg. Co., South Plainfield
WELDON, JOHN M., Power Engineer,
E. I. du Pont de Nemours Co., Carney Point

New York

ALLEN, OLIVER F., Power and Mining Department,
General Electric Co., New York
AYR, SAMUEL, Factory Manager,
Automatic Transportation Co., Buffalo
BENSEL, JOHN A., Consulting Engineer, New York
BUSSEY, CHARLES C., President,
Coal Products Corporation of America, New York
COLDWELL, ARTHUR J., Superintendent,
Coldwell Lawn Mower Co., Newburgh
COLE, FORREST W., Mechanical Engineer,
The Solvay Process Co., Syracuse
COLEMAN, CHARLES P., Vice-President,
Worthington Pump & Mchy. Corp., New York
DECKER, RUDOLPH J., M. E.,
Kaolin Prod. Corp., New York
DEVINE, JOSEPH P., President,
J. P. Devine Co., Buffalo
DRAKE, WARREN C., Mechanical Engineer,
Westinghouse Elec. & Mfg. Co., New York
DYGERT, CHARLES B., Equipment Engineer,
Remington Arms U. M. C. Co., Ilion
EVERETT, CHESTER M., Member of Firm,
Hazen, Whipple & Fuller, Cons. Civil Engrs., New York

GOODSPEED, CHARLES A., Machine Tool Salesman,
Henry Prentiss Co., New York
GREIST, ALVA O., Consulting Engineer, New York
HAYDEN, THOMAS J., Instructor, Practical and Applied Electricity, Department of Education, New York
HEQUEMBOURG, WALTER J., Assistant General Manager,
New York Dock Co., Brooklyn
HIRSCHBERG, CHARLES A., Advertising Manager,
Ingersoll-Rand Co., New York
HUDSON, ALBERT H., General Purchasing Agent,
Wright-Martin Aircraft Corp., New York
INGLES, ROBERT N., Chief Engineer,
M. W. Kellogg Co., New York
ISKOLS, ANATOL D., Mechanical Designer,
Switchboard Dept., General Electric Co., Schenectady
JOHNSTON, ROBERT B., Supervisor of General Machining,
Remington Arms & Ammunition Co., Ilion
KING, NORMAN M., Engineer in charge,
The Singer Building Power Plant, New York
LINDENKOHL, HENRY, Engineer of Construction,
American Locomotive Co., Schenectady
McCLEARY, WILLIAM, Superintendent,
New York & Richmond Gas Co., New York
MYERS, CHARLES T., Production Engineer,
Savage Arms Co., Utica
PECK, ROSS S., Engineer,
Westinghouse, Church, Kerr & Co., New York
PEEBLES, ERFORD J., Factory Engineer,
Divine Brothers Co., Utica
SACCHI, GUSTAVO A., Engineer, Power Div.,
Westinghouse Elec. & Mfg. Co., New York
SHAW, HUBERT A., Metallurgist,
American Can Co., Geneva
SITNEY, MASSEY, Mechanical Engineer,
New York Navy Yard, New York
STALEY, FREDERICK W., Fuel Engineer,
The Texas Co., New York
STEWART, JAMES T., Resident Inspector
The Hartford Steam Boiler Inspection & Insurance Co., Utica
TAYLOR, JAMES D., Advisory and Operating Engineer, New York
TUCKER, JOSEPH H., Construction Superintendent,
Grant Contracting Co. New York
WILFERT, GEORGE, Assistant Chief Inspector,
Remington Arms Union Metallic Cartridge Co., Ilion
WORTH, B. G., Vice-President,
Walter Kidde & Co., Inc., New York
WRIGHT, DONALD C., Production Supervisor,
Remington U. M. C. Co., Ilion

Ohio

AICHBERGER, CARL, Mechanical Engineer,
The Sandusky Foundry & Machine Co., Sandusky
BICKFORD, FRANK, Engineer,
The Recording & Computing Mchs. Co., Dayton
BLANCHARD, CHARLES M., Chief Engineer,
The Standard Fuel Oil Engine Co., Willoughby
BURGER, FREDERICK W., Superintendent,
Delphos Mfg. Co., Delphos
CARMAN, EDWIN S., Secretary and Chief Engineer,
The Osborn Mfg. Co., Cleveland
CASE, GEORGE S., Factory Manager,
The Lamson & Sessions Co., Cleveland
FULTON, WILLIAM B., Supervising Engineer,
The Colin Gardner Paper Co., Middletown
FRYER, WILLIAM H., Chief Engineer
The National Cash Register Co., Dayton
GEOGHEGAN, JOHN T., Mechanical Engineer,
C. N. O. & T. P. Rwy., Cincinnati
GIBBONS, MICHAEL J., JR., Secretary,
M. J. Gibbons Supply Co., Dayton
LOHMANN, ALFRED P., Engineer in Charge, Engineering Dept.,
The B. F. Goodrich Co., Akron
MOORE, CHARLES C., Chief Engineer Power Sta.,
The National Cash Register Co. Dayton
MUELLER, OSCAR W., President,
The Mueller Machine Tool Co., Cincinnati
PERKINS, J. B., President,
The Hill Clutch Co., Cleveland
PATTERSON, A. HUGO, Contracting Engineer,
The Mt. Vernon Bridge Co., Mt. Vernon
PELTZ, ARTHUR C., General Manager,
The Morris Machine Tool Co., Cincinnati
RASTALL, WALTER H., Engineer,
Worthington Pump & Machinery Corp., Cincinnati
RICHARDS, ARTHUR, Consulting Engineer,
Richards Engineering Co., Columbus
ROLLMAN, BRUCE B., Experimental Engineer,
New Idea Spreader Co., Coldwater
SAFBERG, B. F., Superintendent, Barberton Works,
The Babcock & Wilcox Co., Barberton
SHUTT, MILO,
With Alliance Machine Co., Alliance
TREADWAY, LYMAN H., President,
The Peck, Stow & Wilcox Co., Cleveland

Oregon

MEANY, JAMES M., Western Representative,
Clyde Iron Works of Duluth, Minn., Portland

Pennsylvania

ADAMS, LOUIS W., Superintendent of Plant,
Bethlehem Steel Co., South Bethlehem
BELL, CLINTON W., 1st Assistant Chief Engineer, Hauto Power Sta.,
Lehigh Navigation Electric Co., Hauto
CARTER, J. WALLACE, Superintendent,
Penn. Barrel Co., Philadelphia
CARTER, OSCAR S., Assistant to Combustion Engr.,
United Gas Improvement Co., Philadelphia
CRISFIELD, JAMES A. P., Engineer,
The United Gas Improvement Co., Philadelphia
DALE, R. BURDETTE, Chief Engineer,
Erie City Iron Works, Erie
EATON, GEORGE M., Division Engineer, Rwy. Div. Eng. Dept.,
Westinghouse Elec. & Mfg. Co., E. Pittsburgh
FISCHER, VALDEMAR B., Toolroom Foreman,
Midvale Steel Co., Philadelphia
HAYES, LAWRENCE W., Salesman,
Worthington Pump & Machinery Corp., Pittsburgh
HINKENS, EDWARD H., Shop Engineer,
Westinghouse Elec. & Mfg. Co., Pittsburgh
HOUGH, ROBERT H., Consulting and Developing Engineer,
Clarke Thomson Research, Philadelphia
JOHNSON, LEON H., Works Engineer,
Struthers Wells Co., Warren
MARVIN, HOWARD, General Manager,
Boyts Porter & Co., Connellsville
ROGERS, FRANK H., Assistant Hydraulic Engineer,
I. P. Morris Co., Philadelphia
SCHREIBER, HERMANN V., Research Engineer,
E. W. Clark & Co., Philadelphia
SHIMER, ABRAHAM, Assistant Chief Engineer,
The New Jersey Zinc Co., Palmerton
SODERSTROM, KARL A., Designing Engineer,
The Midvale Steel Co., Philadelphia
SPEER, J. RAMSEY, President
Pittsburgh Iron & Steel Foundries Co., Pittsburgh
SPRINGER, LESLIE W., Civilian Superintendent, Hull Div.,
Philadelphia Navy Yard, Philadelphia

Rhode Island

HATCH, WILLARD T., Engineer Power and Construction,
Brown & Sharpe Mfg. Co., Providence

West Virginia

FAIRCHILD, ALBERT R., Assistant Superintendent,
Appalachian Power Co., Bluefield

Wisconsin

BOYER, GEORGE H., Assistant Engineer Power Plant,
Milwaukee Electric Rwy. & Lt. Co., Milwaukee
BULLARD, EARL J., Manager, Field Production Service,
Gisholt Mch. Co., Madison
MACKLEM, GEORGE A., Engineer,
Beloit Iron Works, Beloit
MESSENGER, C. R., Vice-President,
Chain Belt Co., Milwaukee
WILSON, JOHN C., Manager, Thomas Meter Dept.,
The Cutler-Hammer Mfg. Co., Milwaukee

South America

OLDITCH, FREDERICK W., Construction and Designing Engineer, and Partner,
Buxton, Olditch & Cia, Buenos Aires, Argentine

Canada

CAMERON, N. C., Chief Engineer,
Imperial Tobacco Co. of Canada, Ltd., Montreal
DRYER, REGINALD P., Assistant General Sales Manager,
Canadian Allis-Chalmers, Ltd., Toronto
LEE, GEORGE E., Asst. to Vice-President, and General Manager,
Canadian Locomotive Co., Kingston
LINCOLN, ELLIS S., Assistant Superintendent,
Nova Scotia Steel & Coal Co., Ltd., New Glasgow
WARD, FRED B., Chief Engineer and Asst. to General Manager,
John Inglis Co., Toronto

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

California

HALLORAN, LEWIS F., Partner,
Halloran & Golcher, San Francisco
SLAUGHTER, WILLIAM B., Mechanical Engr. and Superintendent,
Marine Mechanical Works, San Pedro

Connecticut

BALL, CHARLES P., JR., Demonstrator,
Bullard Machine Tool Co., Bridgeport

BASMAJIAN, SEROVP P.,
with Winchester Repeating Arms Co., New Haven

BURRILL, ALBERT S., Assistant Chief Draftsman,
Pratt & Whitney Co., Hartford

MALONE, GEORGE B., Assistant Equipment Engineer, Gun Dept.,
Winchester Repeating Arms Co., New Haven

Delaware

MINER, HAROLD L., Fire Protection Engineer,
E. I. du Pont de Nemours & Co., Wilmington

District of Columbia

DAVIDS, ROBERT L., Mechanical Draftsman,
Office of the Chief of Ordnance, Washington

Illinois

BEITMAN, ARTHUR H., Engineer and Manager, Quincy Branch,
Edmund T. Perkins Engineering Co., Chicago

BENNETT, ARTHUR R., Furnace Man,
American Steel Foundries E. St. Louis

SCOTT, EDWIN M., Meter Engineer, Testing Department,
Commonwealth Edison Co., Chicago

WILSON, LEROY A., Assistant, Engineering Experiment Sta.,
University of Illinois, Urbana

Indiana

MARTIN, D. STANLEY, Assistant Superintendent of Services,
Citizens Gas Co., Indianapolis

SAUERS, JOHN A., Instructor Mechanical Engineering,
Purdue University, W. Lafayette

Maine

NEWCOMBE, GARFIELD M., Mechanical Designer,
Eastern Mfg. Co., Bangor

Maryland

STUMP, JOHN, JR., Construction Department,
General Electric Co., Philadelphia

Massachusetts

ANDREWS, BERNARD R., New England Manager,
Buffalo Forge Co., Buffalo Steam Pump Co., Boston

HORTON, LUCIEN B., Superintendent Loading Plant,
United States Cartridge Co., Lowell

PHILLIPS, EDMUND M., Draftsman,
General Electric Co., Lynn

Michigan

BROCKBANK, VICTOR, Chief Draftsman,
Superior Machine & Engineering Co., Detroit

FIELD, LAWRENCE N., Assistant Professor Mechanical Engineering,
Michigan Agricultural College, E. Lansing

GANDHI, JASWANT RAI, Mechanical Draftsman, Power Dept.,
Ford Motor Co., Detroit

Minnesota

KOBEL, W. C., Assistant Superintendent, Gas Power Sta.,
Minn. Steel Co., Duluth

Missouri

CARNEGIE, JAMES, Assistant Engineer to Chief Engineer,
Union Electric Light & Power Co., St. Louis

HUFF, LYMAN C., Chief Draftsman,
Union Electric Light & Power Co., St. Louis

New Jersey

JACKSON, ROBERT E., Assistant Superintendent,
Edison Laboratory, West Orange

LACEY, LESTER K., Cost Accountant,
American Smelting & Refining Co., Maurer

TOMPKINS, HAROLD D., Engineer,
Smooth-On Mfg. Co., Jersey City

WHITE, J. W. HUYLER, First Assistant Chief Engineer,
The American Sugar Refining Co., Jersey City

New York

EVANS, HERBERT W., District Manager,
Reeves Pulley Co., of Columbus, Ind., New York

FINKEL, J. J., Inspection Engineer,
New England Westinghouse Co., New York

FRAYNE, WILLIAM D., Sales Engineer,
Ridgway Dynamo & Engine Co., New York

GEARY, ROBERT J., Engineering Department,
Semet-Solvay Co., Syracuse

GOALWIN, HARRY A., Student at Columbia University and occasional work for Moses, Pope & Messer, Cons. Engrs., New York

GOLDRICH, PHILLIP, Draftsman.
Guarantee Construction Co., New York

GOODSELL, CHARLES D., Master Mechanic,
Columbian Rope Co., Auburn

HATCH, FREDERICK N., Engineer,
Westinghouse, Church, Kerr & Co., New York

MORSE, ALBERT W., Vice-President,
The Anthony Co., Long Island City

NEESON, CHARLES R., Assistant to Supt. of Manufacture,
Ice Manufacturing Co., New York

POTTER, ERFORD M., Supervising Engineer,
Douglas Robinson, Charles S. Brown Co., New York

RYAN, WILLIAM F., Construction Superintendent,
Interborough Rapid Transit Co., New York

SKINNER, HOWARD A., Cadet,
Westchester Lighting Co., Gas Department, Mount Vernon

SONDERMAN, HERMAN C.,
With Brooklyn Rapid Transit System, Brooklyn

STUBER, ADOLPH, Efficiency Engineer, Camera Works,
Eastman Kodak Co., Rochester

THOMPSON, DWINEL B., Mechanical Inspector,
New York Central R.R., New York

TORNBERG, ISIDOR, Designer,
R. Hoe & Co., New York

VANDE MARK, EUGENE S., Manager Technical Department,
National Employment Exchange, New York

WAHL, JAMES H., Machinery Inspector,
Transit Development Co., Brooklyn

WORTHEN, CHARLES B., Chief Inspector, Aeroplanes and Aeromotors, Signal Corps., United States Army, College Point

Ohio

BRODERICK, GEORGE H., Factory Manager,
Corrugated Container Corp., Columbus

McLAUGHLIN, GLENN D., Maintenance Engineer,
Recording & Computing Machines Co., Dayton

MORNINGSTAR, B. FRANKLIN, Engineer Main Power Station,
The River Furnace Co., Cleveland

SCHIRMER, CARL E., Chief Draftsman,
Schaffer Engineering & Equipment Co., Tiffin

TAGGART, ARTHUR B., Secretary,
Advance Machinery Co., Toledo

WIGHT, HARRY C., Superintendent Div. of Water,
Dayton Water Works, Dayton

Pennsylvania

BENNY, IRWIN H., Superintendent Mfg.,
Penn Barrel Co., Philadelphia

BRYANS, HENRY B., Engineer Schuylkill District,
Counties Gas & Elec. Co., Norristown

CHURCHILL, HAROLD W., Executive Engineer, Motor Drill Dept.,
Burke Electric Co., Erie

DOWELL, HENRY L., Instructor in Mech. Engrg.,
University of Penn., Philadelphia

HORTON, ERNEST J., Mechanical Engineer,
Ruud Manufacturing Co., Pittsburgh

MacLEAN, ARCHIBALD, JR., Marine Engineering Dept.,
Westinghouse Machine Co., East Pittsburgh

ORR, HAROLD S., Assistant to Superintendent of Inspection,
Remington Arms Co., Eddystone

SCHULZ, GUSTAV E., Factory Organizer, Instructor of Scientific Management,
Tabor Mfg. Co., Philadelphia

SLAYMAKER, WILLIAM W., Assistant Mechanical Engineer,
Bureau of Surveys, Philadelphia

South Carolina

LE TELLIER, LOUIS S., Professor,
The Citadel, The Military College of South Carolina, Charleston

Texas

GUNTHER, ERNEST, Sheet Metal Mfg.,
H. Welsh Co., El Paso

Virginia

WILLIAMS, SAMUEL S., Chief Engineer of Power Stations,
Roanoke Rwy. & Elec. Co., Roanoke

West Virginia

BALLARD, A. M., Chief Engineer,
Wayland Oil & Gas Co., Charleston

Wisconsin

WEGNER, ARNOLD A., Engineer, Elevating & Conveying Dept.,
Chain Belt Co., Milwaukee

Canada

SMOCK, HAROLD E., Chief Draftsman,
Page-Hersey Iron Tube & Lead Co., Welland

FOR CONSIDERATION AS JUNIOR

Alabama

GLIMM, WILLIAM F, JR., Engineer,
Barrett Co., Fairfield

SPEARMAN, GUY M., Draftsman,
American Cast Iron Pipe Co., Birmingham

Colorado

ROUSE, JOHN E.,
With The United Oil Co., Florence

Connecticut

CLARK, RUSSELL G., Draftsman,
The American Thread Co., Willimantic

HILL, CLARK B.,
with Terry Steam Turbine Co., Hartford
HIRSCH, ROBERT R., Technical Writer, Advertising Dept.,
S. K. F. Ball Bearing Co., Hartford
HOLMS, TURY B., Designing Draftsman,
Terry Steam Turbine Co., Hartford
JOY, JOSEPH, Mechanical Engineer,
Peter A. Frasse & Co., Hartford
LEES, KENNETH F., Chief Engineer,
Greist Mfg. Co., New Haven
MAGZOCCO, DANTE V., Assistant Floor Foreman,
Ashcroft Mfg. Co., Bridgeport

Delaware

TAYLOR, HENRY M., JR.,
with Harlan & Hollingsworth Corp., Wilmington
WISE, ALLEN S., Drafting,
Remington Arms Co., Wilmington

Illinois

EDE, ALBERT B., Engineer,
Cobden Machine Works, Cobden
FLIEGNER, CARL G., Section Chief, Manufacturing Layouts Dept.,
Western Elec. Co., Inc., Cicero
KNIESE, HAROLD G., Engineer,
Central Illinois Light Co., Peoria

Louisiana

HATFIELD, EDWARD R., Draftsman,
Slidell Shipbuilding Co., Slidell

Maryland

WEST, G. ALVIN, Draftsman-Designer,
P. B. & W. R. R. Co., Wilmington

Massachusetts

EDWARDS, HAROLD H., Engineer,
Swift & Co., Boston
GFROERER, HERBERT G., Mechanical Engineer,
Carver Cotton Gin Co., E. Bridgewater
IRWIN, KILSHAW M., Engineer, Station Betterment Dept.,
Stone & Webster Engrg. Corp., Boston
WESTERVELT, NELSON H.,
with Norton Co., Worcester

New Jersey

CLARKSON, ROBERT C., JR., Construction Engineer,
J. E. Campbell Co., Camden
EVANS, JAMES M., Efficiency Engineer,
Hyatt Roller Bearing Co., Harrison
HALAMA, FREDERICK D. H., Draftsman,
Babcock & Wilcox Co., Bayonne
MANDEL, ARTHUR C.,
with Simplex Automobile Co., New Brunswick
SCHLITZ, BERNARD P., Chief Tool Designer
Simplex Automobile Co., New Brunswick
TALBOT, JOHN A., Superintendent Butler Factory,
Bloomingdale Rubber Co., Bloomingdale

New York

CASABLANCA, FRANK J., Chief Draftsman, Marine Dept.,
Kerr Turbine Co., Wellsville
GAISER, J. H., Secretary,
Booth Felt Co., Inc., Brooklyn
GODSON, JOHN A., Draftsman, Williamsburg Power Station,
Brooklyn Rapid Transit Co., Brooklyn
GREENE, GEORGE F., Draftsman,
M. H. Treadwell Co., New York
HASELTON, PHILIP H., Assistant Manager,
Newman Clock Co., New York
KELLY, WILLIAM, Assistant in M. E. Dept.,
Rensselaer Polytechnic Institute, Troy
MAGILL, FRANKLIN R., Engineer, Charge Reduction Gears Design,
Kerr Turbine Co., Wellsville
MARTIN, EDWARD, Efficiency Engineering,
American La France Engine Co., Elmira
MOZEEN, HERBERT D.,
with Mulliner-Enlund Tool Co., Syracuse
QUACKENBUSH, EUGENE S., Engineer,
Friedmann, Robertson & Keeler, New York
SIPE, CHARLES A., Time Study Work,
Remington Typewriter Co., Syracuse
TREWIN, FRANK H., Lubricating Engineer,
Vacuum Oil Co., New York
WALKER, GEORGE G.,
with Vacuum Oil Co., New York
WEBER, HUGH H., Sales Engineer,
The Texas Co., New York

North Carolina

SANDERS, WALTER C., Mechanical Draftsman,
Atlantic Coast Line R. R. Co., Wilmington

Ohio

BRETT, ROY C., Instructor in Mechanical Engineering,
Case School of Applied Science, Cleveland
GALLUP, ALDEN W., Mechanical Engineer,
The Hinde & Dauch Paper Co., Sandusky
MITCHELL, MIRON A.,
with The National Vacuum Machinery Co., Dayton
TERRIBERRY, G. GILSON, Production Engineer,
Niles-Bement-Pond Co., Hamilton
WARD, J. CARLTON, JR., Mechanical Engineer,
Niles-Bement-Pond Co., Hamilton

Oklahoma

LICHTY, LESTER C., Assistant Professor Mechanical Engrg.,
University of Oklahoma, Norman

Pennsylvania

AICHER, ALFRED L., Chief Draftsman,
F. J. Stokes Machine Co., Philadelphia
DISMUKES, ALBERT R., Efficiency Engineer,
The Emerson Co., Pittsburgh
GANTS, ELWYN T., Assistant Test Engineer,
Pittsburgh Crucible Steel Co., Midland
GIBSON, JULIAN B., Special Apprentice,
Niles-Bement-Pond Co., Philadelphia
GRING, WILBUR D., Superintendent Motive Power,
Newport & Shermans Valley R. R. Co., Newport
HENDERSON, DOUGLAS, Instructor, Mechanical Engineering,
The Drexel Institute, Philadelphia
MABREY, NELSON L., Assistant Engineer,
Standard Car Construction Co., Sharon
POWELL, WILLIAM W., Assistant Sales Manager,
Mesta Machine Co., Pittsburgh
SANDER, MALVIN G. F.,
With National Tube Co., Pittsburgh
STROUD, WILLIAM T., Mechanical Engineer,
The Atlantic Refining Co., Philadelphia

Rhode Island

McDEVITT, JOHN N., Vice-President and Assistant Treasurer,
Dover-McDevitt Co., Providence
MANDEVILLE, THEODORE C., Mechanical and Construction
Engrg.,
Sayles Finishing Plants, Saylesville

Texas

CAPEN, FREDERICK B., Mechanical Engineer,
The Texas Co., Port Arthur
EDGAR, OSMER N., Engineer-in-Charge Industrial Dept.,
Houston Chamber of Commerce, Houston

Wisconsin

COVELL, CLIFFORD C., Assistant Draftsman, Car Dept.,
Chicago, St. Paul, Minneapolis & Omaha Ry., Hudson
LAABS, ERIC H., Mechanical Engineer,
Cutler-Hammer Mfg. Co., Milwaukee
LEWIS, DEMPSTER C., Student Apprentice,
Allis-Chalmers Mfg. Co., Milwaukee
WHYTE, TESSEL S., Secretary,
Macomber & Whyte Rope Co., Kenosha

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE

Ohio

GRIESS, JUSTIN, Second Vice-President,
The McMyler Interstate Co., Bedford

PROMOTION FROM ASSOCIATE-MEMBER

Georgia

EAGER, WILLIAM G., Second Vice-President,
Valdosta Lighting Co., Valdosta

Massachusetts

GRUNWELL, PAUL C., Mechanical Engineer,
New Bedford Westinghouse Co., Springfield

New York

KETCHUM, SAMUEL, Mechanical Engineer,
M. H. Treadwell Co., New York
PAUSIN, HUGO R., Superintendent Torpedo Dept.,
E. W. Bliss Co., Brooklyn

PROMOTION FROM JUNIOR

Connecticut

TREDWELL, KENNETH I., Production Engineer's Staff,
Winchester Repeating Arms Co., New Haven

Illinois

DOWSON, HARRY R., Experimental Engineer,
F. W. Matthiessen, La Salle

Michigan

IDDLES, ALFRED, Instructor Eng. Division, Michigan Agricultural College, East Lansing

Minnesota

FULLER, FLOID M., Consulting Mechanical and Electrical Engr., Duluth

STAUDE, EDWIN G., Pres., E. G. Staude Mfg. Co., St. Paul

New York

FARRELL, MORGAN G., Vice-President, Willard Case & Co., New York

LIBBEY, RICHARD H., Engineer, Otis Elevator Co., New York

SHOUDY, WILLIAM A., Assistant Mechanical Engineer, J. G. White Engineering Corp., New York

Pennsylvania

MEHARG, LAURENCE, Assistant to Superintendent of Power, Hazel-Atlas Glass Co., Washington

West Virginia

MORGAN, JOHN T., District Sales Agent, The Ohio Brass Co., Charlestown

SUMMARY

New applications	324
Applications for change of grading:	
Promotion from Associate	1
Promotion from Associate-Member	4
Promotion from Junior	10
Total	339

NECROLOGY

J. LINWOOD BROWN

J. Linwood Brown was born in England in 1846. His experience as an engineer began in railway service, in which he progressed to responsible work in mechanical and construction engineering. He built and operated the Southern and West Wisconsin Railroad; held the position of Engineer of Construction with the Mexican Central, the Veronej and Rosstoff Railroad and the Panama Railroad, and was subsequently Superintendent of Motive Power and Maintenance of the Ohio Southern and Pittsburg & Western Railroads. His later work was as Superintendent of the Bureau of Water Supply and Distribution of the city of Allegheny, Pa. He died September 11, 1916. His membership in the Society dates from 1902.

EDWARD THOMAS HENDEE

Edward Thomas Hendee, who was born at Claremont, N. H., February 22, 1880, died at Minneapolis, Minn., November 12, 1916. Upon graduation from New York University in 1900, he received the degree of B.S., and immediately assumed the duties of instructor and assistant professor of chemical and mechanical engineering at New York University, receiving the degrees of M.E. and M.S. during that time. In 1901 he also received the degree of Sc.D. at Columbia University.

In 1902 he associated himself with the firm of Joseph T. Ryerson & Son, Chicago, Ill., as mechanical engineer, and in 1906 became manager of the machinery department. Between the years 1909 and 1913 he acted in the capacity of assistant to the president of the company and in 1913 became secretary, continuing so until his death. Under Mr. Hendee's management both the domestic and foreign machine business and the railway-supply business of the company were very widely extended.

Besides his affiliation with Joseph T. Ryerson & Son, Mr. Hendee was vice-president and director of the Lennox Machine Co. and director of the American Glyco Metal Co. He was a member of the University Club, of the Alumni Board of Trustees of New York University, and of a number of athletic clubs in Chicago. In 1908 he was elected an Associate of this Society and in 1915 became a Member.

WILLIAM KNOX MILLHOLLAND

William Knox Millholland, president of the W. K. Millholland Co., Indianapolis, Ind., and for many years distinguished as a machine-tool designer, died October 9, 1916. He was born in Baltimore, Md., in 1856 and educated in the public schools. In 1874 he started his mechanical training as apprentice with Flynn & Emerick, of Baltimore, Md., in their drafting room and machine department. He remained in their employ five years, during which time he completed an evening course in the Maryland School of Arts and Design. In 1881 he became superintendent of the Falls Rivet and Machine Co., Cuyahoga Falls, O., where he designed and built special machine tools and brought out several inventions. In 1887 he moved to Chicago, Ill., and entered the employ of the M. C. Bullock Mfg. Co., as tool maker and designer. He continued with this company until 1893, when he became superintendent for the Geo. D. Whitcomb Co., designing and building coal-cutting machinery, knitting machinery, etc. In 1898 he became sales manager for the Gisholt Machine Co., Madison, Wis., in which work he continued until 1906, when he organized the International Machine Tool Co., Indianapolis, Ind., and became its secretary. In 1909 he established and became president of the W. K. Millholland Machine Co., in which he was actively interested until the time of his death. Four of his seven sons are continuing the business.

Mr. Millholland was among the first members of the Society, being elected in 1883.

FRANK L. STRONG

Frank L. Strong, who was born in Amherst, Mass., in 1845, was educated in the public schools of Andover, Mass., and later in Phillips Academy. After leaving school, he decided to become a machinist and accordingly apprenticed himself to the Davis & Furber Machine Shop, at North Andover Depot, where he remained two years. During the Civil War he resigned to enlist, and worked his way to third assistant engineer in the Navy, receiving his honorable discharge at its close. He returned to Chicago in 1867 and finally settled there, having been in charge of various large manufacturing plants before he became superintendent and part owner of the Hercules Refrigerating and Ice Machinery Co.

In June, 1898, at the outbreak of the Spanish-American War, he again enlisted as engineer, this time becoming chief engineer of the Illinois Naval Reserves. He returned to Chicago in 1899, entering the field of consulting mechanical engineering, and in 1900 was retained by the Quartermaster-General of the Army as consulting engineer and superintendent of erection of the refrigerating and ice-making plant at Manila. When this work was completed, he opened an office for himself under the name of the Frank L. Strong Machinery Co. (1902) and engaged in private practice, also representing a number of home manufacturers.

Besides being a Member of the Society, to which he was elected in 1912, he was a member of the Business Men's Association in Manila, a member of the Loyal Legion, the Sons of the American Revolution and a number of local clubs in Manila. He was a prominent worker in the Masonic Order, and was Master of the first lodge in Manila.

AMONG THE SECTIONS

AT the recent conference of Sections' delegates a committee was appointed to draft a report embodying suggestions as to activities which may be properly undertaken by the Sections of the Society. Messrs. Hans R. Setz, Chairman of the St. Louis Section, and William G. Starkweather, Secretary of the Boston Section, prepared the report which was adopted by the conference. It contains so many suggestions of value that the Committee on Sections have recommended its reproduction in full. The report follows:

SUGGESTIONS REGARDING LOCAL SECTION ACTIVITIES

Irrespective of local conditions there are certain points which may well be generalized as applying to all the Section meetings. The two principal ones are that the meeting shall attract as large an attendance as possible, and that each member shall leave each meeting with the feeling that the hours devoted to it were well spent.

In these days of engineering and trade journals and excellent technical books, it hardly seems possible to attain the above ends by the presentation of lectures or discussions on highly technical subjects. Exceptions, of course, occur where for instance some new or very important development in connection with local industries is taking place. Generally speaking, however, such papers seldom interest more than just those who are closely connected with the particular subject, which could hardly be otherwise since we have to accept the condition which calls for specialization in our professional work.

The important thing then is to find the subject for our meetings on other fields than the strictly technical, and of such there is indeed a great number. We are all aware of the fact that individually, and especially as a professional unit, engineers are finding practically no recognition in the community, and it is quite certain that this condition will continue to exist as long as we are satisfied to let all our interest be centered on the study and pursuance of our professional work. It is here we see the principal mission of our Sections at the present time and for some time to come.

This brings us at once face to face with the question of speakers, and we believe there is no better way of manifesting and cultivating the spirit of interest and coöperation in the happenings of the community than by securing local speakers. In every town where the existence of a local section of mechanical engineers is warranted, there is enough industrial activity to bring forth problems in which the human side is of predominating importance. Such problems are the question of unemployment, insurance against accidents and disability from old age, education and recreation of workmen and their children, supply of food and commodities, hygienic problems, etc., which are all brought about by the concentration of comparatively great masses of people on small areas, in other words, by the industries for which we engineers are responsible. Much work along such lines has already been done by liberal church societies and philanthropic organizations, although very much lacking in concerted and harmonious effort to bring about a maximum of good. There should be no difficulty to procure speakers on the above subjects who are familiar with the particular local conditions. Securing local speakers on such problems will probably at first not look very attractive, but as such a plan is carried on, the increasing knowledge of the human side of our work is bound to awaken an interest and produce results which cannot fail to be ultimately of the utmost importance to our profession.

Another series of meetings may be arranged to cover questions that will eventually lead to standardization in the determination of cost of manufactured articles. This will become of utmost importance in trying to clearly understand and arrive at a fair method of establishing tariff rates, in which it is to be hoped engineers may have a word to say.

Many other similar questions of local as well as national importance could be cited here which will all help to broaden the interest of engineers and put them on an equal footing with doctors and lawyers who, on account of the strong human element in their professional work, are today exerting such a strong influence in the activities of the community.

The routine of meetings must be adjusted to local requirements, for which no general rules can be laid down.

In the general plan of the meetings there are many who believe a luncheon very desirable either before or after the meeting; this promotes acquaintance, assists in securing pleasant remembrances, helps membership and provides diversion. A supper preceding the meeting seems preferable, since this helps to bring the members together promptly and permits an early closing. This supper need only be of the simplest kind, and in the arrangements it would seem desirable to provide individual tables seating not more than from four to six people.

In deciding on the number of meetings per year, it seems preferable to have a few well-attended interesting affairs rather than frequent forced evenings. Invitations to these meetings are preferably sent out by return postal cards which should reach the members not less than three days, and preferably about seven days, ahead of the meeting.

Where there are no other engineering societies in the community, the mailing list for invitations to the meetings of the local section should include every man in any way actively interested in manufacturing, consulting or directing of industries. Where other engineering societies exist, these mailing lists must, of course, be arranged so as not to interfere with the activities of these sister societies. Frequent revisions of these mailing lists should be made so as to keep them up to date; the names of visitors who are too persistent in availing themselves of our hospitality without response to occasional gentle hints to join the Society should be removed from the list after one year.

In conducting the meetings, papers should start early, say 7:30 or 7:45 p. m.; the time allotted for the presentation of a paper should not exceed three-quarters of an hour. It is advisable to notify those most interested in the subject of the evening that they may be called upon to participate in the discussion; this should be done sufficiently in advance to enable them to prepare themselves. This will lead to a short, snappy session which can be closed early and will leave a good impression.

Particular attention should be paid to the publicity of local Sections' activities. Advance notice should be sent the newspapers, reporters invited, and abstracts furnished, if desired, by the secretary. Publicity for the engineer has long been neglected and is partly to blame for the lack of coöperation in, and disorganized condition of the profession.

Respectfully submitted,

WM. J. STARKWEATHER,
HANS R. SETZ.

BIRMINGHAM, JANUARY 24

The Birmingham Section met on the evening of January 24 when J. T. Anthony, a combustion expert of New York, gave an illustrated lecture on The Locomotive Firebox and Combustion Chamber.

The author considered that future operating conditions of railroads are problematical but the indications are that in addition to present demands for high-hauling capacity there will be a demand for higher speeds. The controlling factor will then be the firebox and its ability to burn the coal properly and liberate the heat required over long periods of time. He presented arguments regarding the effect of heat radiation from the fuel bed, flameways and brick work and the necessity of large firebox volume and long flameway. He showed a number of illustrations of furnace layouts of locomotives in actual operation and the results obtained in fuel economy, boiler capacity and cost of maintenance.

PAUL WRIGHT,
Section Secretary.

BALTIMORE, FEBRUARY 9

Harrington Emerson, Mem.Am.Soc.M.E., of New York, addressed the Baltimore Section at their meeting on February 9, on The Flow of Values Through an Industrial Plant. He

emphasized the fact that the important factors in an organization are the men connected with it. This consideration led Mr. Emerson to study the means of analyzing men before taking them into his organization and he developed a system of character analysis. A series of examples of the application of this method was shown by means of lantern slides.

Turning next to the organization itself, Mr. Emerson threw a diagram on the screen which illustrated in an exceptionally clear manner how values entered the business in the form of cash, from the sale of its securities and finished products, and how this money appeared as values throughout the process until the goods finally reached the customers. The diagram also illustrated the relative potential values of each step in the process, and the functions of the organization and the accounting department were very forcibly brought out by the stop-cocks and returns on the diagram. Mr. Emerson further compared the former view of accounting that simply insisted on authority, allotment and accuracy, and the modern view that demanded real facts regarding production. An interesting discussion followed.

A. G. CHRISTIE,
Section Secretary.

BUFFALO, JANUARY 31

Non-Ferrous Metallurgy was the subject of W. M. Corse's paper read before The Engineering Society of Buffalo at their meeting on January 31. Mr. Corse dwelt particularly upon the separate types of brass and bronze when alloyed with phosphorus, manganese, aluminum and silicon. Slides illustrated many of the findings presented in his paper and proved the rapid advances made in non-ferrous metallurgy.

There was a general discussion of Mr. Corse's paper, following which A. L. Johnson briefly explained the activities of the American Society for Testing Materials.

The Engineering Society of Buffalo, which is an outgrowth of the Buffalo Section of the Am.Soc.M.E., held a meeting on February 15, at which the formation of a General Technical Society was discussed. The project includes provision for all branches of the engineering profession, chemists, electro-chemists, etc. Preceding this discussion, Henry A. Brown gave a brief description of The Design of the Latest Development of Milling Cutter, illustrated by slides, showing the attainments of the tool in actual operation.

LOUIS J. FOLEY,
Assistant to Secretary.

BOSTON, FEBRUARY 7

More than 500 engineers attended the annual banquet at the Boston City Club on the evening of February 7, representing The American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the Boston Society of Civil Engineers. They unanimously pledged their support to President Wilson in the present crisis and formally voted to send a copy of the following resolution, presented by Dr. Ira N. Hollis, Pres., Am. Soc.M.E., to President Wilson:

> "In view of the grave crisis which our country is facing, and in recognition of the stand recently taken by the President of the United States for the protection of American rights and American lives on the sea,
>
> "BE IT RESOLVED that we, the members of the Convention of the Societies of Electrical, Civil and Mechanical Engineers, held jointly in Boston, Wednesday, February 7, 1917, *first* do pledge ourselves to the support of the President and Congress in their hope that our rights may be maintained by peaceful means, and, *second*, we pledge ourselves likewise to the utmost of our powers and our service, in case our country is forced into war as the only means of maintaining all our rights, freedom and safety the world over.
>
> "BE IT FURTHER RESOLVED that a copy of this resolution be sent to the President at the White House at Washington and to every Senator and Representative from New England."

Dr. Hollis in his subsequent speech declared: "We engineers can take only one attitude, it is that every citizen is permitted, even expected, to develop himself to the highest degree of service for his nation and mankind. There is only one way to do this, and it is for us to unite in the kind of goodwill and good-fellowship that will enable us to work together towards the glory of our country—in peace, we hope, but in war if it is absolutely necessary."

Other speakers of the evening were Prof. Elihu Thomson, who stated in part: "We want a definite program laid out by intelligent men, by engineers, and followed without delay. What we need in this country is recognition of the fact that we are in an engineering age, that encouragement of research in scientific matters cannot be carried to excess. Our Government should be willing to spend large sums in putting forward the sciences and their applications." Dr. Hugh Cabot, chief of the Harvard Surgical Unit, who related some of his experiences at the front; Mr. Richard A. Hale, President of the Boston Society of Civil Engineers, who laid stress upon the importance of the engineers' work in case the country should be brought into the war and strongly advocated a central conference of all engineers to fix and distribute their services; and E. W. Ewartz, who spoke on Submarines and illustrated his subject throughout with many interesting slides.

W. G. STARKWEATHER,
Section Secretary.

CHICAGO, JANUARY 19

Col. Henry A. Allen, Consulting Engineer, Garbage Disposal Plant, City of Chicago, gave an illustrated lecture on Problems in Waste Disposal before the Chicago Section at their meeting on January 19. He based his remarks on the information obtained in his study of Chicago's $7,000,000 project. He gave a description of the important disposal systems and told of the new plant being constructed for the city, together with what by-products may be obtained from the plant. By means of stereopticon views he showed the methods of construction and interesting details in apparatus and equipment used in the plant.

ROBERT E. THAYER,
Section Secretary.

CINCINNATI, JANUARY 18

At a joint meeting of the Cincinnati Section and the Engineers' Club of Cincinnati on January 18, J. H. Hunt, Research Engineer for the Dayton Engineering Laboratories Co., gave an interesting paper on Modern Internal-Combustion-Engine Ignition. The paper considered the requirements of the two general types of electrical ignition: the so-called wipe-spark and the jump-spark ignition. The point was emphasized that the condenser is merely a part of the breaker mechanism and has no useful purpose other than that of enabling the latter to act properly.

Oscillograph records were shown of the oscillation occurring in the primary circuit at the break when the secondary is disconnected, of the primary current and the voltage of the primary coil during normal operation together with the secondary current, and of the reduction in the final value of the current caused by chatter. Records were also shown of apparatus operated at speeds equivalent to 4000 r.p.m. of the engine, the spark obtained with the magneto at low speed, and the prolonged flame or arc persisting after the first spark in the magneto runs at very high speed.

The oscillograms illustrated some of the interesting relations in magneto design which are not generally known.

The paper concluded with a discussion of the effect of ignition upon power, and in this connection it was shown that the only thing ignition can do is to ignite, and that when properly timed any absolutely certain ignition will give all the power the motor is capable of developing at a given speed and carburetor adjustment.

JOHN T. FAIG,
Section Secretary.

CINCINNATI, FEBRUARY 15

The February meeting of the Cincinnati Section was held jointly with the Engineers' Club on February 15. A. Lewis Jenkins, Mem.Am.Soc.M.E., Associate Professor of Mechanical Engineering at the University of Cincinnati, read an interesting paper on Combined Stresses. Abner Doble, of the General Electric Co., Detroit, Mich., followed Professor Jenkins with a paper on the Doble Steam Car, of which he is the inventor and which is a new development. This car uses kerosene as fuel, has a water-

tube boiler and uniflow engine. Stereopticon slides illustrated its many novel and interesting features.

JOHN T. FAIG,
Section Secretary.

ERIE, FEBRUARY 13

At the meeting of the Engineers Society of Northwestern Pennsylvania, held February 13, to which the members of the Erie Section of the Am.Soc.M.E. were invited, a resolution was passed to affiliate with the Erie Section, to work for the better interests of both societies and of the engineering profession.

The Erie Section will hold a big meeting before the summer recess.

J. F. WADSWORTH,
Section Secretary.

LOS ANGELES, JANUARY 24

The Los Angeles Section met on January 24 to discuss How Cities in the United States Are Disposing of Their Sewage. The speakers of the evening were T. D. Allin, Commissioner for the city of Pasadena, and R. V. Orbison, City Engineer of Pasadena. Both Mr. Allin and Mr. Orbison took an extended trip through the United States for the purpose of investigating this subject and their remarks were founded on personal observations.

FORD W. HARRIS,
Section Secretary.

MINNESOTA, JANUARY 25

On January 25, the Minnesota Section and the American Institute of Electrical Engineers held a joint meeting at the University of Minnesota. The early part of the evening was devoted to a discussion by Charles L. Pillsbury, Mem.Am.Soc.M.E., on What is Valuation. Mr. Pillbsury has just recently perfected for the United States Government a complete physical valuation of all the public utilities within the jurisdiction of the district of Columbia. E. H. Smith followed Mr. Pillsbury with a talk on Oxy-Acetylene Welding and Cutting, illustrating it throughout with practical demonstrations. General discussion followed each of these subjects.

D. M. FORFAR,
Section Secretary.

NEW ORLEANS, JANUARY 22

Oil Fuel was the subject of the main paper, presented at the January 22 meeting of the New Orleans Section by B. S. Nelson, Mem.Am.Soc.M.E. Written and verbal discussions by a number of engineers followed.

H. L. HUTSON,
Section Secretary.

PHILADELPHIA, FEBRUARY 1

The Philadelphia Section and The Franklin Institute held a joint meeting February 1, when the By-Product Coking Industry was discussed by C. J. Ramsberg, vice-president of the H. Koppers Co., Pittsburgh, Pa. He treated of the design, construction and operation of the modern by-product plant, coal used in by-product coking, coke structures as affected by coal, conditions affecting the efficiency of operation and recovery, and the future of the industry, illustrating his lecture throughout by means of slides and moving pictures. Special attention was devoted to benzol and benzol recovery.

JOHN P. MUDD,
Section Correspondent.

NEW YORK, FEBRUARY 13

The New York Section was well represented at the February 13 meeting when Dr. Ira N. Hollis, Pres.Am.Soc.M.E., discussed The Engineer and Organization, and C. W. Hunt, Mem.Am.Soc.M.E., read a paper on Narrow Gauge Motor Cars.

Following the lines of his well-received addresses before some of the other Sections, Dr. Hollis drew a picture of the progress of mankind as dependent in a very large degree upon engineering. "Engineering," he said, "by eliminating drudgery, has done much for the betterment of humanity." He concluded his remarks with a plea that engineers, through their organization, take a more active part in public affairs and announced a plan for closer coöperation between the national engineering societies in matters of common interest.

Mr. Hunt's paper reviewed the growing field for narrow gage motor cars, the several designs intended to meet certain conditions of service, trucks, transmission and loading, and the most economical sizes of car to employ. He also touched upon cable railways and gave data for the solution of problems connected therewith.

A. D. BLAKE,
Section Secretary.

PROVIDENCE, JANUARY 24

Some Mechanical Analogies in Electricty was the subject of Prof. William S. Franklin's talk before the Providence Engineering Society at their meeting on January 24. By means of some very ingenious mechanical pieces, he illustrated the analogies between mass and inductance, elasticity and capacity, and the effects of these characteristics on both mechanical and electrical systems. He pointed out that there were between twenty and thirty mathematical equations applying to mechanics which take exactly the same form when applied to electricity. President Faunce of Brown University followed Professor Franklin with an expression of gratification at the coöperation of the members of the engineering profession of Rhode Island and Brown University.

ALBERT E. THORNLEY,
Corresponding Secretary.

ST. LOUIS, JANUARY 31

On January 31, the St. Louis Section and the Associated Engineering Societies of St Louis held a joint meeting, when George R. Wadleigh, Mem.Am.Soc.M.E., read a paper on Cotton-Mill Design. He described the processes involved in the manufacture of plain unbleached cotton goods and the major features of cotton-mill design. At the conclusion of the paper there was general discussion by the members of the Section.

Good-will and jollity reigned at the Annual Dinner of the Engineering Club of St. Louis and the Associated Engineering Societies, held at the City Club on January 24.

L. A. DAY,
Section Secretary.

ST. LOUIS, FEBRUARY 10

Louis C. Nordmeyer, Mem.Am.Soc.M.E., of the firm of Tait & Nordmeyer Engineering Co., gave a lecture with illustrations on China at the meeting of the St. Louis Section on February 10. Mr. Nordmeyer related some of his interesting experiences while engaged in important engineering work in Shanghai.

On February 14 the Associated Engineering Societies of St. Louis held a joint meeting with the American Society of Engineering Contractors, when Mr. Alroy S. Phillips, Attorney, spoke on The Workmen's Compensation Law. Mr. Phillips was chairman of the legislative committee appointed under former Governor Hadley of St. Louis to investigate workmen's compensation laws throughout the country.

L. A. DAY,
Section Secretary.

STUDENT BRANCHES

The large group of Student Branches was augmented by the Council at its meeting on February 16 by the approval of petitions received from the engineering students at Johns Hopkins University, the University of Pittsburgh, and Washington University. This brings the total number of Student Branches up to forty-three.

Plans for a Joint Meeting of Student-Branch members are being perfected. This meeting will occur on Friday afternoon and evening, March 30, at the Engineering Societies

Building, 29 West 39th Street, New York. In addition to the four Metropolitan Student Branches—Columbia University, New York University, Polytechnic Institute of Brooklyn and Stevens Institute of Technology—who have charge of the arrangements, it is expected that the Student Members at Pennsylvania State College and Yale University will also participate. Other Student Branches are urged to arrange to participate and individual student members and graduate student members will also be welcome.

BUCKNELL UNIVERSITY

At the meeting of the Bucknell University Student Branch on February 5, H. C. Liebensberger gave a very comprehensive talk on The Manufacture of Coke in Southern Virginia. He described the methods employed in taking coal from the mine, giving his hearers an insight into the various operations in coal handling before it is finally taken from the beehive ovens and loaded on cars. Professors Kepple and Burpee, Mem.Am.Soc.M.E., took part in the discussion which followed.

On February 7, Professor Burpee gave an instructive illustrated lecture before the students on The Combustion of Fuel, and Heat Transmission with Special Reference to Steam Boilers.

C. M. KRINER,
Branch Secretary.

COLORADO STATE AGRICULTURAL COLLEGE

The meeting of the Student Branch of the State Agricultural College on January 15 was devoted to an inspection of the new heating plant of the college. Prof. L. D. Crain, Mem.Am.Soc.M.E., discussed in detail the workings of the plant. He called attention to the two Stirling boilers, each of 234 hp. and equipped with automatic stokers, the steel bunkers with capacity of 250 tons, the pumps and receivers, which are to take the return water from the steam-heating system and pump it back to the boilers, the two tunnels leading off to all the buildings on the campus, and the hopper under the railroad track, where coal will be received and conveyed by machinery to the bunkers in the boiler room. He further explained that the boilers, coal-handling machinery, pumps and other equipment were designed so that tests of each part of the plant or the plant as a whole may easily be made by the students of mechanical and electrical engineering.

E. C. JOHNSON,
Branch Chairman.

COLUMBIA UNIVERSITY

The United Engineering Society held a joint meeting with the Mining Society on January 17, when the speakers of the evening were Charles Piez, Mem.Am.Soc.M.E., on The Art of Conveying Materials, J. P. Channing on Human Engineering, and Fred H. Rindge on The Industrial Service Movement of the Y. M. C. A.

J. L. KRETZMER,
Branch Chairman.

JOHNS HOPKINS UNIVERSITY

The first meeting of the Johns Hopkins University Student Branch was held December 15, 1916, and the following officers elected: President, Edward Stewart; vice-president, A. McWolfe; treasurer, N. Owings; and secretary, B. A. Sullivan.

On January 17 the Branch was addressed by J. O. Martin, of the Chesapeake & Potomac Telephone Co., of Baltimore, Md. His subject, The Romance of the Telephone, was exhaustively treated, and the many interesting slides shown gave the students a good insight into past and present telephone work.

B. A. SULLIVAN,
Branch Secretary.

KANSAS STATE AGRICULTURAL COLLEGE

Walter W. Carlson, Mem.Am.Soc.M.E., professor of mechanical engineering and shop practice at the Kansas State Agricultural College, gave an illustrated lecture on The Future Incomes of College Engineers, before the Student Branch of that college on January 18. The curves on the charts displayed, were drawn from data taken from several of the most representative colleges in America, and formulæ were derived whereby a student may roughly foretell his income at any year after graduation. The following table shows the formulæ for the average student: (*N* equals number of years after graduation).

All Colleges	750 + 170*N*	Salary (year)	Max. in	20	years	
K. S. A. C.....	600 + 200*N*	"	"	"	20	"
Trade School...	150 + 125*N*	"	"	"	10	"
Shop Training...	150 + 90*N*	"	"	"	8	"
Laborer	200 + 100*N*	"	"	"	5	"

W. N. CATON,
Branch Secretary.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Massachusetts Institute of Technology held their first smoker of the new term on the evening of February 9. The first speaker was R. H. Sawyer, '17. He briefly outlined the process of paper manufacture and described some of the important machinery used in the work. The second speaker was T. K. Corey, of the Wm. Filene Sons Co., Boston, who is in charge of the 2500 employees of the company and was therefore in position to ably handle the subject of Human Engineering. He particularly emphasized the necessity of coöperation between the employer and employee in order to assure satisfaction and contentment on both sides. Mr. Corey kindly extended to the students an invitation to visit the plant to view a few of its mechanical features, which include a complete power station and boiler house, located six floors below the street, a refrigerating plant and a large wireless station.

EDW. W. ROUNDS,
Branch Secretary.

NEW YORK UNIVERSITY

An interesting talk on Water Power Plant Design was given at the February 9 meeting of the Student Branch of New York University by H. M. Garson. An hour of lively discussion followed.

JOSEPH GILMAN,
Branch Secretary.

POLYTECHNIC INSTITUTE OF BROOKLYN

At the February 13 meeting of the Student Branch of the Brooklyn Polytechnic Institute the two speakers were Bronson L. Huestis, Mem.Am.Soc.M.E., and Samuel Stern of the class of '17.

Mr. Huestis' subject was Materials and Manufacture of Mixed Paints. He described in detail the various kinds of pigments and solvents, enumerating their advantages and disadvantages. He said paints containing adulterants, such as clay, whiting, barium sulphate, etc., in their proper proportions, make better paints than the pure substances alone.

A discussion on The Development of the Phonograph was given next by Mr. Stern. He explained the operation of the diaphragm, the construction of the sound-box, the speed regulation of the motor and the different types of motor used.

President Hollis delivered an interesting lecture before 300 students of the Institute on February 14, on the subject of Service to Our Country. He stated that we all ought to be ready to give our service to our country whenever needed. Although there had been no definite call for service, he sincerely believed that if the test should come no man in the United States would be found wanting. Dr. Hollis emphasized the word Service, bringing out the fact that Congress, in discussing compulsory military service laws, laid too much stress on the word *military*, rather than *service*. If our country should be involved in war, fully one-third of the men would do more useful service in the factories than in the Army or Navy.

He stated that in his opinion war would never cease, unless some substitute were found where men could sacrifice themselves for their country, with the same spirit that they do on the battlefield. He really believed that that incentive existed, if we would only look for it. He pointed out the difference between democracy, autocracy and nationalism, defining a democracy as a place where man has permission to develop himself to a maximum efficiency. Democracy was bound to fail unless men could develop them-

selves to that efficiency to which they are forced under nationalism. There is much room for better efficiency in this country, since in no country in the world is there as much waste as in the United States.

In reporting the January 6 meeting it was neglected to state that Mr. Rosenzweig's talk was accompanied by a number of slides showing the poppet-valve engine of his own design. He also gave a description of his return flow and uniflow types as built by the York Mfg. Co., York, Pa.

GEORGE CHERR.
Branch Secretary.

PURDUE UNIVERSITY

The Reasons Why Chinese Industries Have Not Progressed, was the subject of the talk T. S. Yue, a senior mechanical student, gave before the Student Branch of Purdue University at their meeting on January 22. The reasons he gave were the retardation of ethical teachings, political oppression, and the social and home bondage. As a remedy for the first two he suggested the republican form of government now existing, and as an aid to the latter the completion of the railroads now contemplated.

The meeting held by the Purdue Branch on February 7 was of an informal nature. Professor Aitkenhead, of the Farm Mechanics' department of the School of Agriculture, initiated those present into the mysteries of the square, the single and double bowline, the catspaw and other useful knots, as well as several types of rope splicing.

W. G. SCHUTT.
Branch Secretary.

STATE UNIVERSITY OF KENTUCKY

The Student Branch at the State University of Kentucky has held three business meetings during the college year. Several other meetings have been held which have been devoted entirely to the study of technical magazines, each member reporting on the contents of the particular journal assigned to him. In this way a large number of the engineering problems confronting the technical graduate are brought into discussion.

At the meeting on February 8 an interesting discussion of the development of the steel industry was given by Governor A. O. Stanley.

D. S. SPRINGER.
Branch Secretary.

STEVENS INSTITUTE OF TECHNOLOGY

The Stevens Engineering Society, which includes the Student Branch of the Am.Soc.M.E., announces that it will resume its schedule of inspection trips on February 21. Among the trips planned are those to the Shadyside Plant of the Barrett Mfg. Co., Loose Wiles Biscuit Co., Hoboken Factory Terminal and the Nagel Packing House.

ALVIN G. SEARLES,
Branch Secretary.

UNIVERSITY OF CALIFORNIA

The first regular semi-monthly meeting of the Student Branch of the University of California for the second semester was held on January 31. Herman Greenwood tendered his resignation as chairman and W. Kenneth Potts was elected to take his place. At its close, Leroy Hill read a paper discussing at length the theory, practice and use of the various types of aeroplane-motor radiators, describing and illustrating the models and showing by comparison the various proportions and sizes used by different manufacturers.

JOHN H. FENTON,
Branch Secretary.

UNIVERSITY OF COLORADO

Mr. Welch of the Strait Scale Co., Boulder, Colo., gave an interesting illustrated talk on The Construction and Operation of Scales at the January 11 meeting of the Student Branch of the University of Colorado. A large aluminum model, which Mr. Welch brought with him, served to show in detail the fine points of construction and the method of operation of the scale. He claimed that the fundaments of scale operation are the power of ratio, and the perfection of the alignment of the knife edges, and that scale errors depend solely upon the distance between pivots and not on scale ratio.

WAYNE S. BEATTIE,
Branch Secretary.

UNIVERSITY OF ILLINOIS

On the evening of February 8 the Student Branch of the University of Illinois met for the election of officers for the coming semester. The new officers are: President, Ralph M. Overton; vice-president, F. E. Evans; secretary, H. C. Dieserud, and treasurer, W. Minkema. The work of the semester is quite promising, several lectures being already scheduled.

H. C. DIESERUD.
Branch Secretary.

UNIVERSITY OF MAINE

The University of Maine Branch held their regular monthly meeting January 17, the subject for discussion being The Farm Tractor. Numerous pictures of the tractor in action were shown by means of a reflectoscope, which testified to its adaptability and usefulness to farmers all over the country. Several interesting designs of the machine were shown, their history given, and salient points discussed.

R. E. FRASER.
Branch Secretary.

UNIVERSITY OF MICHIGAN

Ball Bearings was the subject of the first lecture of the year, given January 16, before the University of Michigan Student Branch by F. M. Sawin. Stereopticon slides illustrated the modern improvements on ball bearings and the process of manufacture from the raw material to the finished product.

The January 18 meeting was devoted to the election of the following officers: chairman, W. A. McKinley; vice-chairman, W. C. Good; secretary, Karl Bintz; treasurer, E. F. Jagodzinski.

KARL BINTZ,
Branch Secretary.

UNIVERSITY OF MINNESOTA

The Student Branch of the University of Minnesota held a meeting on January 20 when the following officers were elected: president, Edwin F. Jones, vice-president, I. N. Eustis; corresponding secretary, H. G. Fortune; recording secretary, J. Walfred; treasurer, G. N. Moffet. Following the election, Prof. J. J. Flather, Mem.Am.Soc.M.E., head of the mechanical engineering department of the University, read and discussed the Report of the Boiler Code Committee.

C. Q. SWENSON,
Corresponding Secretary.

WORCESTER POLYTECHNIC INSTITUTE

On Friday evening, February 2, the Worcester Polytechnic Student Branch held their regular monthly meeting, Charles M. Allen, Mem.Am.Soc.M.E., and Professor of Hydraulic Engineering at the Institute, giving an interesting illustrated talk on The Testing of Water Wheels After Installation.

As a consulting engineer, Professor Allen had occasion to test many installations of water wheels in hydroelectric plants, and the lantern slides evidenced the work done under the most varying conditions, from that in which the building had been built around the machinery in some backwoods ravine to an installation of the most up-to-date sort, in which the building was provided with spur tracks, traveling cranes and other appliances, making the installation of the dynamometers a comparatively easy matter. He emphasized the facts that water wheels should be tested after installation to show whether or not they were so set as to give their full power and efficiency rating; that all power stations should be provided with the proper cranes and appliances for installing heavy machinery and for future repair purposes.

H. P. FAIRFIELD,
Branch Secretary.

EMPLOYMENT BULLETIN

THE SECRETARY considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping anyone desiring engineering services. The Society acts only as a clearing house in these matters.

POSITIONS AVAILABLE

In forwarding applications, stamps should be enclosed for transmittal to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed with the Society. Copy for notices must be in hand by the 15th of the month.

PARTNERSHIP. Present owner desires capable assistant in running a business which is well established. Investment of $20,000 to $25,000 required, as well as practical working interest in business near Philadelphia engaged in operation on a limited scale for making silica brick. 522

DRAFTSMAN, capable of designing machines of comparatively large size for boring and milling purposes, and fixtures and tools for use on such machines. Location Providence. 525

CHEMICAL ENGINEER who is experienced in aniline-dye manufacturing to become department engineer. Position pays $40-$75 per week, depending upon the man's ability. Name confidential. Location New York State. 530

DRAFTSMAN experienced in factory design and installation of elevator and conveying machinery in general cement-plant work. Location Pennsylvania. 710.

DRAFTSMAN. Prefer man with one or two years' experience out of college. Location Virginia. 747

DESIGNER. Expert mechanical engineer qualified to design machinery for the manufacture of shaving brushes. Location New York. Name confidential. 757

FOREIGN REPRESENTATIVE. New York firm desires a competent man with knowledge of machinery to take charge of machinery business in France; must speak the French language fluently. 758

ENGINEERS wanted to train and develop in the fundamentals of a firm primarily engaged in the distillation of coal tar with the resultant principal production of bituminous road and roofing materials, with the ultimate object of filling operating positions in various plants as foremen, head chemist, assistant superintendents, or superintendents. Chemical engineering training desirable but not essential. As contemplated work will eventually be of an executive nature, ability to handle men is a desirable asset. 796.

DRAFTSMEN, with special experience in the design of chemical plant equipment; familiar with power-plant design, piping layouts, foundation work, light structural-steel work and timber-platform construction. Location Brooklyn. 803.

FOUNDRY MANAGER with capital to invest in gray-iron foundry. Location Northern Ohio. 808.

DRAFTSMAN on elevating and conveying machinery and light structural and plate work. Permanent employment to desirable man, with opportunities for advancement. Salary $125 per month to an experienced man. Location Hudson, N. Y. 809.

ELECTRICAL ENGINEER possessing extensive experience with electrolytic plants for producing oxygen and hydrogen, wanted by New York concern. 811.

CHIEF ENGINEER for large central-station power house in an Atlantic seaboard city. Must be qualified to take charge of an 80,000-kw. plant and experienced in handling Curtiss turbines, jet and surface condensers, Taylor stokers, and other apparatus found in large central-station plants. State age, experience and salary expected. If employed, give name of company and reason for changing. All replies strictly confidential. 813.

ASSISTANT to the head of engineering department of Boston concern. Young technical graduate, mechanical or engineering course. Salary $100 a month; good chance for advancement. 817.

SALES CORRESPONDENT and TRAVELING SALESMAN, two men who know machinery, preferably equipment used either in paper mills or factories working on paper as a raw material such as printers, box makers, bag, envelope or paper-specialty manufacturers. Engineering degree not necessary, but character, ability, energy and clean record are. Salary $1,500 per year after instruction period, increasing with ability. Prefer letter outlining record before interview. Location Brooklyn, New York. 820-821.

OFFICE INSPECTOR to show how to improve work. Experienced in foundry work and machine-shop tool work. Salary according to man, say $2,000 to start. New York location. 822.

CHIEF DRAFTSMAN for large malleable-iron foundry, with pattern, machine, and smith shops and finishing department. Output consists principally of railway specialties. Experience required in charge of drafting-room work, steel freight car construction, both body and trucks, design of special shop equipment such as molding machines, tools, jigs and fixtures, the installation of power-transmission machinery. Prefer a young man who has had experience either with a railroad or a car builder, who is personally quick, accurate and of pleasing address, able to secure results from the men under him. Salary, $150 to $175 per month; prospect good for promotion to the right man. Location New York State. 823.

ENGINEER OF TESTS. Young man of more or less technical training in mechanical engineering, to be of assistance to the engineer in general testing work on boilers, engines and turbines. Salary to start, about $15 per week. Location New York. 824.

DESIGNER and ASSISTANT ENGINEER on power-plant work, both mechanical and electrical side; must have had experience in this line of work. Location New York. 825.

EXECUTIVE to take charge of grab-bucket department of structural-steel plant. 845

TWO SALESMEN or SALES REPRESENTATIVES, 25 to 30 years of age, unmarried, energetic and intelligent. Technical and selling experience, with knowledge of accessory business required, although would consider competent and experienced salesmen without technical training. Position requires ability to sell to jobbers and develop large territory. Salary $45 to $50 per week with traveling expenses. Territory: Middle West and South, and West, respectively. 863

SALES ENGINEERS, technical training; two or more years' practical experience in selling, to coöperate with salesmen in various districts in the U. S. to further the sale of lineshaft roller bearings. Salary $1,200 to $1,800. 864

DRAFTSMAN, technical graduate, mechanical engineer, one or two years' experience in designing power-house installations; water-, steam- and air-piping systems, for large manufacturing concern near Philadelphia. State age, experience to date, references, salary desired, and how soon available. 865

DRAFTSMAN, familiar with marine-engine and boiler work, preferably man with some experience in hull work. State age, salary, experience and references. 869

EXPERIENCED TIME-STUDY MAN, familiar with the production of small interchangeable parts, wanted for manufacturing plant in Philadelphia. Position will lead to one of responsibility. 826.

CHIEF DRAFTSMAN or ASSISTANT ENGINEER to handle primarily steam piping. Salary $175. Location New York. 827.

ASSISTANT ENGINEER, with technical training and a successful record in the operation and maintenance of power plants and factories—also handling of men. Hours at present 7 a.m. to 5:30 p.m. Salary to start, $200 per month. Excellent opportunity for advancement for a man of initiative and energy. Location Brooklyn. 830.

DRAFTSMAN on machine-shop equipment—jigs, tools, etc. State experience and salary expected. Location Canada. 838.

SUPERINTENDENT and MECHANICAL ENGINEER. Good opportunity for young man to start with a new, growing concern; one who has experience on conveyors and sawmill and pulp-mill machinery. State fully experience and give references. Location Michigan. 842.

SALES ENGINEER for established Detroit concern, manufacturers of boiler accessories. Salary commensurate with experience and ability. Must be thoroughly acquainted with boilers and be able to successfully meet and impress technically trained executives, and capable of closing contracts ranging from $300 to $10,000. Write explicitly, giving experience, minimum salary to start, and references. Correspondence confidential. Address E. C. W., 80 First Street, Detroit, Mich. 853.

MECHANICAL DRAFTSMEN for small machine-tool works. Salary $18-$20 and $20-$25. Men that have some "know how and why." Location Newark, N. J. 855-856.

DRAFTSMAN to design transmission machinery. Salary $30 per week. Location New York. 857.

ENGINEERING APPRENTICES. Openings for two recent technical graduates, with opportunity for experience in steam-turbine manufacture, testing and designing. Salary $15 per week for first nine months. Will also consider 1917 graduates, to begin work in June or July. Location Connecticut. 859.

CHEMICAL ENGINEER for a permanent position in the Philippines. One who has had considerable experience in extracting plants and understands the extraction of oils from cake with trichlorethylene, carbon tetrachloride, naphtha, etc. Must be more or less familiar with the refining of vegetable oils and soap manufacturing. Correspondence will be carried on through New York office. 860.

DRAFTSMAN for machine design and small tool work. Young man with some experience. "Live wire." Salary depends on man. Location New York. 861.

ENGINEER experienced in milling graphite by wet process, to take up construction of new plant. Salary depends on man. Location Alabama. 812.

EFFICIENCY ENGINEER for general efficiency work in car manufacturing plants. In replying state age, experience and salary expected. Probable location, Canada. 870

MECHANICAL ENGINEERS of highest type—especially experienced in steel machinery, designing and building, wanted for newly organized plant; must be able to handle men. Give age, previous experience. Probable location Middle West. 871

MASSACHUSETTS concern wants technically trained man, about 30 years of age, married, who has brains, personality and tact. Write stating full particulars. 872

WORKS ENGINEER. Highly experienced man to take charge of power and construction matters in rapidly growing plant employing 3000. Must be active and tactful and of demonstrated ability. Preference to man with technical training. In first letter give age, salary and complete statement of experience. Location Middle West. 877.

CAPABLE MAN, with experience in motor-truck operation and repair, for position as traveling service inspector. Location Wisconsin. 878

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 15th of the month, and the form of the notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

MECHANICAL ENGINEER or ASSISTANT SUPERINTENDENT, technical graduate, age 30, married. Seven years' experience in manufacturing plants as draftsman, mechanical engineer and division superintendent and in planning production and time-study work. Ambitious and desirous of locating with Eastern concern offering good opportunity. C-104

PURCHASING AGENT, with several years' experience with large manufacturing concern, where practical mechanical knowledge was applicable. Familiar with stock-room systems, a close buyer and resourceful. Available on reasonable notice; location immaterial. C-105

INDUSTRIAL PLANT ENGINEER, graduate M. E., aged 30, desires position with growing concern as engineer or assistant engineer, depending upon size of plant. Nine years' practical experience in shops, power plant, construction and maintenance; also some experience in purchasing. Successful in handling men and a good correspondent. Location East or South preferred. C-106

ENGINEER, with twenty-five years' experience in designing, manufacturing and operating steam, gas and electrical machinery with some of the largest builders. Competent to take charge of entire manufacturing plant. Desires position where new ideas and special services may lead to an interest in firm. Ohio, Indiana or Western Pennsylvania preferred. C-107

MECHANICAL ENGINEER or ASSISTANT SUPERINTENDENT. M. E. graduate, age 31, married. Seven years' experience on automobiles, motor trucks, accessories, production tools, small punch and die work, inspection gages and a large variety of small and medium special and semi-automatic machinery. Capable of directing as well as executing work. Would like to join small or medium-sized growing organization. At present employed as assistant chief engineer. Present salary $2100. C-108

EXECUTIVE or MECHANICAL ENGINEER, experienced in factory organization and design of special elevating and conveying machinery, tools and jigs. Technical graduate; desires opportunity with reliable firm. Location New York or vicinity. C-109

MECHANICAL ENGINEER desires position in connection with maintenance or production of railway rolling stock and equipment or production of mechanical equipment incident to preparedness for national defense. At present employed. Twenty years' experience in design and construction of industrial and railway mechanical equipment; highly specialized in practical application of applied science, locomotives, cars, trucks, boilers, engines, turbines, tanks and special machinery, shop layouts and power plants, towers and structural work. C-110

MECHANICAL ENGINEER, technically educated, desires to make change. Fifteen years' experience in the designing, estimating and development of steam shovels, dredges, hoisting engines, derricks and miscellaneous machinery, with some steel-foundry and machine-shop practice. Location in Middle West preferred. At present employed. C-111

ASSISTANT SUPERINTENDENT. M. E. graduate, with eight years' shop experience. Familiar with modern methods in quantity production and capable of producing results and handling men. C-112.

EMPLOYMENT MANAGER. Technical graduate, with the proper training and experience, age 31, married. Available after May 1. C-113

MECHANICAL ENGINEER, age 37, would consider partnership or interest in engineering business or position on salary or salary and commission basis. Technical graduate, fourteen years' foreign and domestic experience in designing, selling and erecting water turbines, governors, penstocks and accessories and in making preliminary investigations and reports on water-power projects and efficiency tests on existing plants with a view to making improvements. Well grounded in steam and electrical engineering; several months in charge of gasoline-tractor design. Thoroughly practical, with executive ability, and not afraid of work or responsibility. At present employed but desires change. Location preferably East or South. Best references. C-114

MECHANICAL ENGINEER. Technical graduate in mechanical engineering. Desires position with industrial plant as plant or maintenance engineer. At present employed. Several years' experience in drafting, structural work, and as engineer for large explosives company. Preferable location, Middle West. C-115.

RESEARCH ENGINEER, PROFESSOR of MECHANICAL ENGINEERING, EXPERIMENTAL or WORKS ENGINEER. An experienced mechanical and civil engineer, now engaged in munition manufacture, is open for engagement. Graduate of leading university, member S. A. E., experienced in teaching and in engineering work of all kinds. Would consider locating in England or France. C-116

CHIEF ENGINEER, who has held the positions of chief engineer, master mechanic and chief draftsman in large industrial plants. Thorough technical and practical experience, covering construction and operation and upkeep of steam and hydraulic power plants. Specialty, steam and fuel economy. Would consider a change from present position. Salary $2400 per year. C-117

ASSISTANT WORKS ENGINEER, college graduate, 6 years' experience; 3 years of arrangement and installation of turbines, boilers,

coal-handling equipment, gas producers, heating and lighting systems; 1 year of machine design, and 1 year of building construction. At present employed. Desires permanent location in Philadelphia or vicinity. C-75

POSITION IN PUBLICITY DEPARTMENT of large mechanical or electrical concern or with a publicity engineer wanted by M. I. T. graduate with broad newspaper experience; future the primary consideration. At present employed in an engineering position. Best of references. C-76

MAINTENANCE ENGINEER or MECHANICAL ENGINEER, Junior Member, Columbia M.E., age 25. Thorough shop, power plant and construction experience, design of special machinery, supervising construction and installation. At present employed. Salary $1500. C-77

POWER PLANT ENGINEER, practical in the designing, building and maintenance of power plants in detail. Now employed. Available at short notice. C-78

PARTNER. Graduate mechanical engineer, age 35, having several years' broad and successful experience as factory manager, wishes to correspond with view to handling the factory end for persons intending to organize a manufacturing business. C-79

MECHANICAL ENGINEER, age 22, technical graduate, member A. S. T. M., with drafting-room and some factory experience and knowledge of accounting, desires situation with manufacturing or engineering firm in or near Boston, if possible. At present employed; good reasons for desiring to make change. C-80

WORKS MANAGER, CHIEF ENGINEER OR GENERAL SUPERINTENDENT, desires to locate within a radius of 100 miles from New York City. A-1 systematizer, organizer and production man with excellent executive ability and able to produce results. American, 44 years of age, with 18 years' practical executive experience in the positions of chief draftsman, general superintendent and works manager on light and medium-heavy interchangeable parts as used on typewriters, moving-picture machines, gasoline and electric autotrucks, water meters, linotype machines, automatic machinery and machine tools, etc. C-81

MASTER MECHANIC or CHIEF DRAFTSMAN, with 15 years' experience on automatic machinery. Salary $2600. C-82.

ENGINEERING EXECUTIVE and SALES ENGINEER, aged 31, married. Have organized and managed both machinery and retail sales forces. Shop experience in machine-tool works. Started and developed a successful retail business which has been recently bought. Location preferred New York City or New Jersey. C-83

STOREKEEPER and PLANNING DEPARTMENT MAN, married, ten years' experience. Salary $35 per week. C-84

DESIGNING ENGINEER, age 30, married. Ten years' experience, English and American, in commercial trucks, tractors and motor fire apparatus; exceptional experience on front-wheel-drive trucks. Fully conversant with interchangeable manufacture. Assoc. Mem. A.S.M.E., Inst. Mech. Engineers (London). Minimum salary $2400. C-85.

ASSISTANT to EXECUTIVE or WORKS MANAGER, age 29, married. Technical graduate, six years' experience in industrial engineering design and construction of buildings, installation of machinery, purchase of equipment and handling of men. At present employed, but wishes position in operating work. Best references. Immediate salary subordinate to future prospects. C-86

MECHANICAL ENGINEER, age 32, now mechanical superintendent of one of the largest cotton mills, would like opportunity to prove that he is capable of handling higher position in mill or high class consulting engineer's office. Considers hard work a pleasure. C-87.

STUDENT MEMBER. Will graduate in June in mechanical engineering course of Bucknell University. One year of practical drafting and two years' practical experience in general repair shop. Free to go wherever there is a chance for advancement. References upon application. C-88

MECHANICAL SUPERINTENDENT or CHIEF ENGINEER, graduate in mechanical engineering, age 38. Fifteen years' experience, ten of which were in charge of power generation, construction and maintenance in large industrial plant. Good references from present employer. C-89

SALES ENGINEER, practical machinist, age 31, married. Technical graduate, with experience in drafting room, plant operation and selling. Now holding position where not only first-class salesmanship but also good engineering ability is very essential. Desires change and would be available in 30 days to one who is looking for an aggressive, capable man of integrity who will push a line with merit, preferably on salary and commission, or on straight salary or straight commission basis. C-90

SUPERVISING ENGINEER, age 28. Technical man, hustler, at present with manufacturing drug concern in charge of construction, light, heat, power, sprinklers and plumbing. Desires change for bigger opportunity. Good, varied experience in labor-saving methods, planning factory layouts, buying and maintenance of equipment and power plants. C-91

PRODUCTION or WORKS MANAGER, age 40. Twenty-one years' experience in time keeping, costs, buying, selling, piece work, planning and production. Thoroughly capable in both office and factory organization; competent to assume responsibility and produce results. Minimum salary $2800. C-92

TECHNICAL GRADUATE, age 23, desires position in manufacturing line. Twenty months' practical experience. Good knowledge in design of small electrical machines. Study of power-plant operation and design. Thorough knowledge of internal-combustion motors and automobiles. Salary $100 per month to start. Location preferred New York. C-93

COMPETENT ASSISTANT to EXECUTIVE. Graduate of Mass. Institute of Technology (1910), has made good in a large munition plant. Now employed but wants a change. Can give references. Salary $2500. C-94

WORKS MANAGER, with successful experience in manufacture of interchangeable parts and shrapnel shells. Chicago vicinity preferred though not essential. C-95

SALES ENGINEER. Mechanical engineer, opening sales office in Chicago in near future, wishes to handle power-plant machinery and specialties on salary or commission basis. Familiar through experience in plant engineering and management with conditions to be met in manufacturing and power plants. C-96

PLANT ENGINEER. Competent to lay out electrical and mechanical transmission and power-plant work in general, and to maintain and improve structures and grounds. At present employed directing work. Prefers large industrial concern. C-97

WORKS MANAGER OR GENERAL SUPERINTENDENT. Production engineer, successful executive; experienced in revising plant management and in the introduction of modern systems. Technical graduate, 20 years' experience in positions from foreman to manager of works employing several hundred men, covering manufacture of machine tools, internal-combustion and steam engines, electrical machinery and construction of works. Available in about 60 days. C-98

EXECUTIVE ENGINEER. Graduate in mechanical engineering, 1907, with exceptional training in mechanical and electrical fields as executive and engineer in construction, sales and accounting work. A consequential thinker, with energy, initiative and aggressiveness. Can consider a proposition where intelligence and ability to "cash in" ten years of hard-earned and valuable experience will bring results. C-99

PARTNERSHIP. Mechanical engineer desires partnership in consulting engineering or contracting firm doing business with industrial concerns. Will make investment. Specialties: power-plant design, construction and operation; industrial plant layout; design of special machinery. Familiar with brass and copper mill practice. C-100

MECHANICAL ENGINEER. Technical graduate, with six years' experience in the design and manufacture of and experimental work on valves, lubricators and general brass goods. At present head draftsman. Systematic and reliable, possessing originality and initiative. Desires position with a responsible future. C-101

ASSISTANT SUPERINTENDENT or EXECUTIVE, American, age 36. Technical education, twelve years in drafting room, including position as chief draftsman; six years' shop experience, one as foreman of shop. Practical mechanic, familiar with the design of special machinery, tools, jigs, fixtures, etc., for manufacturing duplicate parts on the interchangeable system. Salary $2000 per annum. Location preferred New York or vicinity. C-102

ASSISTANT to MANUFACTURING EXECUTIVE, technical graduate, age 31. Familiar with manufacturing practice, production, construction and handling men. Good knowledge of purchasing. Desires position with future. C-103

ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

ARRANGED IN THE ORDER OF THEIR APPEARANCE IN THE SURVEY

AERO-HYDRO FAN SEPARATOR
DUST SEPARATION BY FAN
HIGH-TEMPERATURE FURNACE-FUME TREATMENT BY FAN
FLOW OF AIR THROUGH NOZZLES AND ORIFICES
NEEDLE-NOZZLE CONTROL OF AIR DISCHARGE
DISCHARGE OF STEAM THROUGH SHARP-EDGED ORIFICE
WHITING-STANDARD FARM TRACTOR
ROLLERS INSTEAD OF WHEELS FOR FARM TRACTORS
TRUCK-SPRING LUBRICATION
LARGE BELT CONVEYOR FOR COAL-LOADING
CONVEYOR BELT OF UNUSUAL LENGTH
PORT KEMBLA COAL-LOADING PLANT
ELIMINATION OF CORROSION IN HOT-WATER-SUPPLY PIPE
FIXATION OF OXYGEN IN WATER-CIRCULATION SYSTEMS
DRYING IN INDUSTRIAL PLANTS
PROGRESSIVE AND APARTMENT DRIERS
CYLINDRICAL DRYING
BRITTLENESS OF ELECTROPLATED STEEL SPRINGS
CAST IRON FOR ENGINE CYLINDERS
GROWTH OF IRON ALLOYS
MEASURING GASES BY A STANDARD ORIFICE
DETERMINATION OF DENSITY OF FLUE GASES
TWO-LIQUID DIFFERENTIAL GAGE
RIVETS, GAS- AND OIL-FURNACE-HEATED
HYDRAULIC-ELEVATOR PUMPS, MOTOR-DRIVEN
HYDRAULIC ELEVATORS, STEAM AND ELECTRICAL OPERATION COSTS COMPARED
HIGH-LIFT CENTRIFUGAL PUMP
AUTOMATIC HYDRAULIC BALANCING DEVICE FOR PUMPS
PENNSYLVANIA RAILROAD REFRIGERATOR CARS
REFRIGERATOR INSULATION ON BOARD SHIP
MARINE TURBINES, FORCED LUBRICATION
DOUST JOINTS
HIGH-PRESSURE STEAM STOP VALVES
HEAT DENSITY
FREE ENERGY, DETERMINATION BY THE CLAUSIUS EQUATION OF STATE
THIRTEENTH ANNUAL MOTOR BOAT SHOW
SILENT VALVES FOR MARINE ENGINES
FIRST PAN-AMERICAN AERONAUTIC EXPOSITION
SOCIETY OF AUTOMOTIVE ENGINEERS
AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

In the past month in the Grand Central Palace, New York City, two expositions were held which were closely related in many respects. The first was the Motor Boat Show and the second, the first Pan-American Aeronautic Exposition. Both bore in the first place testimony to the triumph of internal-combustion engineering and in particular to the development of the explosion engine. Both showed that some of the problems of this comparatively new branch of engineering may be considered as having been solved satisfactorily. Such are the problems of ignition, lubrication and water cooling. The question of air-cooling design appears to be still under a cloud of doubt. The problem of fuel is fully solved in so far as gasolines are concerned, but when we come to kerosenes there is still a wide field open for further research and invention. It appears, however, from a paper read at the last annual meeting of the S.A.E., that even here a large amount of success has been achieved; there are several designs of kerosene carburetors practically available which can efficiently handle the heavier fuels (as compared with the gasolines), and the most important problem now before the designer of a kerosene-burning engine is not the carburetor but the combustion chamber.

As regards the Aeronautic Show, the most striking feature of it to those who have closely followed the vicissitudes of the early days of heavier-than-air-machine building are the truly tremendous strides made in the last two years. To the aeronautical industry the war has certainly been a big opportunity. No precise data are of course available as to the number of machines used by the belligerent countries, but Captain Clarke, U.S.A., at a recent meeting of the S.A.E., gave those present to understand that the French alone have not less than 20,000 planes. From various sources one can glean that the number of British machines is at least as large, which would mean that the two great allied nations alone have something like 40,000 machines, representing an establishment worth, with its shops and auxiliaries, not less than the stupendous sum of $500,000,000; all of this spent in something like twenty-four months. There certainly never has been an instance where a new industry, less than ten years old, has been given such an opportunity. How fully it has made use of it can be determined only after an investigation of what has been done in Europe, which is unfortunately impossible at the present time.

THIS MONTH'S ARTICLES

In the section Air Engineering is described a fan capable of separating water and dust from the air by a process similar to that of centrifugation.

In the same section is abstracted a university thesis on the flow of air through nozzles and orifices. Particular attention is called to this work, as it contains English translations of the most important investigations on this subject for the last century. Unfortunately, some of the formulæ are printed in such a manner as to make their meaning doubtful.

Under Automobiles is described a British farm tractor employing broad-treaded rollers instead of the usual driving wheels. In the same section is described a unique system of spring lubrication.

From a British publication is abstracted the description of a belt-conveyor coal-loading plant having several unusual features of design.

F. N. Speller, in a paper before The American Society of Heating and Ventilating Engineers, describes an experimental plant installed for testing a method of elimination of corrosion in hot-water-supply pipe by fixation of oxygen in water before the water is admitted to the pipes.

J. O. Ross, in a paper before the same society, discusses the fundamental principles underlying the design of driers and the fields of service of various types of this class of machinery.

Results of an experimental investigation of the brittleness produced in steel springs by electroplating are presented in the section Engineering Materials. While no explanation of this brittleness has been found, the results are of a certain practical interest.

Cast iron for engine cylinders is the subject of a paper by J. Edgar Hurst before the Manchester Association of Engineers. The paper presents interesting material on the subject of the growth of alloys.

Formulæ on measuring gases by a standard orifice are reported in a composite abstract of papers by Prof. Thomas G. Estep and H. G. Geissinger.

The somewhat unexpected fact that gas-heated rivets remained hot longer than those oil-heated is brought forward in the *Bulletin of the Southern Gas Association*.

From *The Engineer* (London) is taken a description of a high-lift centrifugal pump, of interest particularly because of the automatic hydraulic balancing arrangement used.

Data on comparative costs of steam and electric operation of hydraulic-elevator pumps are abstracted from an article in the *Electrical Review and Western Electrician*.

A description of an experimental refrigerator car of the Pennsylvania Railroad, combining features of passenger- and freight-car construction, will be found in the section Railroad Engineering.

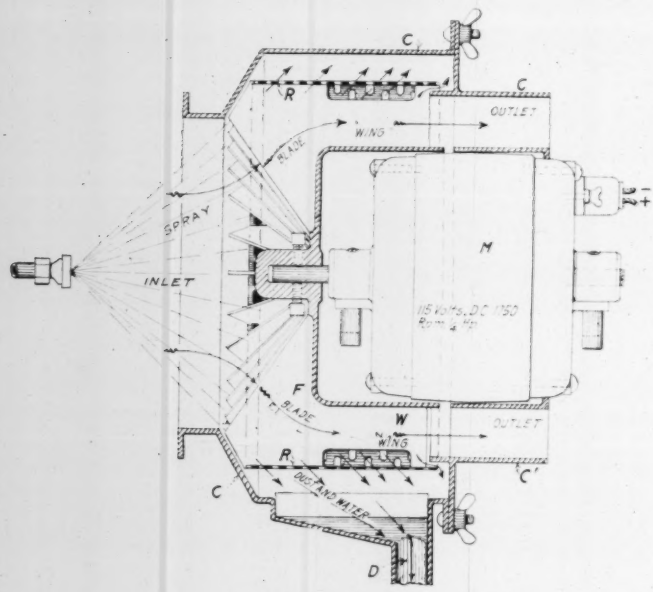


FIG. 1 AERO-HYDRO FAN-SEPARATOR

An illustrated article on the design and construction of high-pressure steam stop valves is abstracted from a paper read before the (British) Institute of Marine Engineers. From an editorial in *Engineering* are taken some passages on forced lubrication for marine turbines.

Brief reports of the meetings of several engineering societies held during the past month will be found at the end of the Survey, as well as more complete accounts of the Motor Boat Show and Pan-American Aeronautic Exposition.

Air Machinery

AERO-HYDRO FAN-SEPARATOR, Wm. J. Baldwin

Description of an improved fan capable of separating water or watery matter or dust from the air. The apparatus dealt with in the article is designed for a hospital ship and is located in a deadlight. The diameter of the hole in the ship's side, which is the inlet, is 8½ in., and the greatest diameter of the apparatus over its flanges is 14 in. Its capacity is 35,000 cu. ft. of air per hour and it permits of keeping the portholes open even in rainy or bad weather.

In Fig. 1, which is a longitudinal section through the apparatus, C and C' represent the stationary case and F the fan revolving within the case. The motor M is fastened to the outlet port of the case C, and the shaft carries the fan F and the rotor R with the wings W. The revolving part is made of aluminum and weighs 7 lb. The plates of the fan are radial and straight so that the apparatus can be run in either direction, any way the current happens to be applied.

When water or spray enters the inlet it strikes the blades of the fan, and, being heavier than the air, goes off almost perpendicularly to the axis of rotation, striking the rotor and being thrown through it about as indicated by the straight arrows. In this way the water escapes at the pipe D and runs outward through a small piece of flexible hose to the deck of the ship or overboard. The air follows the direction of the feathered arrows. It has been found that with the finest spray nozzles that can be obtained the hygrometric condition at the outlet of the cabin end of the apparatus is from 45 to 50 per cent of saturation, and the peculiarity of the apparatus is that even in fog the water will seize on the fog and carry it with it through the rotor, the air escaping into the cabin still showing about 50 per cent of saturation.

The author enumerates many uses for the apparatus described, especially in the field of dust separation. Among these he describes experiments with high-temperature-furnace fumes in a plant where, after the detinning process is completed, the old cans are made into sash weights. By means of the separator they have succeeded in recovering the dust and gases from the top of the cupola, with temperatures probably above 1200 deg., and have taken the tin, lead, zinc, etc., from the gases by the use of the wet process, throwing them into a tank as a mud. This example is cited to show that fumes from gases and metals can be treated at very high temperatures. (*Journal of the American Society of Heating and Ventilating Engineers*, vol. 23, no. 2, January 1917, pp. 209-215, 6 figs, *de*)

THE FLOW OF AIR THROUGH NOZZLES AND ORIFICES, J. Lynn Reynolds and Homer J. Ling

Historical review of the development of the theory of flow of air through orifices, comprising a number of translations and abstractions of various writers of the nineteenth and present centuries, beginning with Koch, Buff, and Saint Venant and ending with Captain Morley, thus bringing the review down to within a year of the present day.

The second part of the work is devoted to a discussion of the design of needle nozzles.

As regards the general theory of flow of air through orifices and nozzles with special regard to problems of measurement, the writers believe that the main reason why the nozzle-and-orifice method for measuring the discharge of air has been discredited is due to the ambiguous presentation of data by different experimenters, which led to the use of improper coefficients with the given orifices or nozzles in cases where, if proper coefficients were used, the results would have been satisfactory. Further, the actual discharge of air through a given nozzle or orifice is less than the theoretical discharge under identical conditions of pressure and temperature. This is due to the fact that as a general rule the stream of air has a smaller cross-section than that of the orifice itself. Also, because of internal and external frictions, the effective velocity of flow is less than the theoretical value. With the thin-edge orifices the coefficient of velocity is practically unity, that is,

the orifice is considered to be frictionless; in which case the coefficient of discharge may be considered equal to the coefficient of contraction.

When these two factors, *vena contracta* and diminished velocity, are taken into account, it necessarily follows that the measured discharge is a smaller quantity than the value given by the theoretical formula. The writers note that if a = coefficient of contraction, and b = coefficient of velocity, then ab = coefficient of discharge.

As to the factors that influence the quantity of flow through an orifice, the following are listed as the most important:

1 Initial pressure of air supply, and in some cases the ratio of the back to the initial pressure.

2 The shape of the orifice, whether it is cylindrical, conical, of convergent or divergent type, or a combination of the two. The length, or rather the ratio of diameter to length, or if an orifice in a thin plate, whether it is bevel- or straight-edged.

3 The condition of the interior surface—smoothness. And also whether the entrance is well rounded and free from sharp breaks in outline of the nozzle curve.

It appears that the coefficient increases with the initial pressure and also with the ratio of back to initial pressure, and that a short orifice with well-rounded approaches will give a coefficient of discharge of approximately 0.98.

Another important factor brought out is that since the time of Zeuner and Fliegner's experiments it has been well established that when the ratio of the final pressure P_2 to the initial pressure P_1 has a value of 0.527, the discharge is a maximum; and for all values $P_2 < 0.527\ P_1$ the discharge remains a constant maximum value. It is well to note, though, that in the case of orifices in thin plates, W (see notation below) appears to keep on increasing after the pressure becomes lower than $0.527\ P_1$, although the increment of increase has a decreasing value as zero is approached and is very much less than the increment from P_1 to the critical pressure.

Now if

W = weight of air discharged per sec.

A = throat area of orifice in sq. ft.

P_1, P_2 = pressures inside and outside orifice in lb. per sq. ft.

n = ratio of specific heats = 1.404

T absolute temperature at P

V volume in cu. ft. at P

the weight of gas discharged in unit time for frictionless adiabatic flow is

When $T = 460 \quad 60°$

$n = 1.404$

$$r = \frac{P_2}{P_1}$$

P = pounds per square inch.

$$W = 0.07058\ d^2\ P_1\ a \sqrt{r_1^{1.405} - r^{1.512}}$$

and the best values of the discharge coefficients as shown by this review are as follows:

For Orifices in Thin Plates (Straight-Edged):

Low pressures (1-12 in. water) ..... $\mu = 0.60$

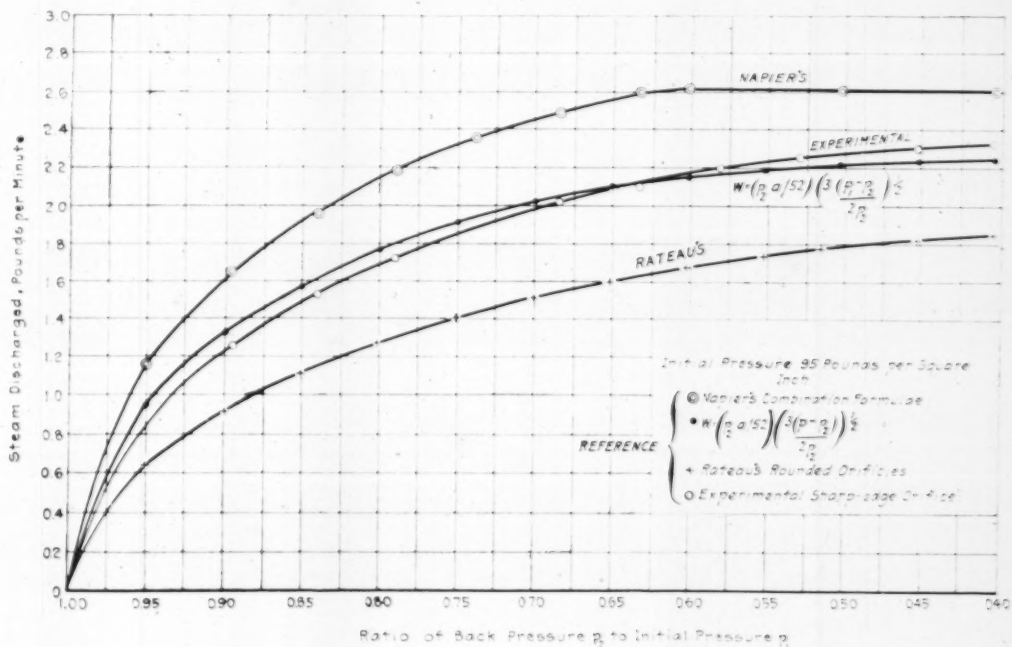


FIG. 2 COMPARISON OF FORMULAE FOR FLOW OF STEAM THROUGH ORIFICES

Medium pressures (15-50 lb.) ..... $\mu = 0.63$

High pressures (50-150 lb.) ..... $\mu = 0.65$

For Nozzles:

Short cylindrical ..... $\mu = 0.75$

Short, well rounded, convergent ..... $\mu = 0.98$

Convergent 6°-10° ..... $\mu = 0.90$

As regards the investigation on needle nozzles, the writers had before them the problem of designing a needle-nozzle control of air discharge from a turbo-compressor set that would meet the following requirements:

1 To deliver 30 hp. at 3400 r.p.m., that is, 2500 cu. ft. of air at 60 deg. fahr. and 14.7 lb. barometric pressure, having a delivery pressure of 2 lb.

2 Of such shape of needle that the issuing core stream from the nozzle could in any position of the former be explored as to cross-section, velocity, and pressure conditions existing in it.

Thus the problem resolved itself into two divisions, the design of the nozzle proper and the design of the needle. An

adiabatic formula for frictionless flow was adopted as the basis of design.

The needle was designed by using a combination of curves that would give in outline one similar to the present water-nozzle needles and of such shape as to offer small resistance to flow. It soon appeared, however, that while this would satisfy conditions for full load, in going from this output to no-output the needle would be so located that the velocity from initial to final point would have a decreasing increment at most positions. This was due to the fact that the area between the nozzle and the needle at the inlet was less than the net area of the outlet. Thus it became necessary to adopt a design which in any position of the needle would give such a succession of areas between the nozzle and the needle from the entrance to the outlet, that the velocity would have an increasing increment in traveling this distance and that as nearly as possible the flow would approach the frictionless adiabatic as an ideal.

The following plan was followed: The nozzle was designed for full load, and then a series of areas determined that would give $\frac{3}{4}$, $\frac{1}{2}$, and $\frac{1}{4}$ loads, respectively. The next step was to so lay out the needle that at these different positions the effective area—the difference between the nozzle's and the needle's areas—would be a series that would fulfill the flow and load requirements for that position. This was done by shifting

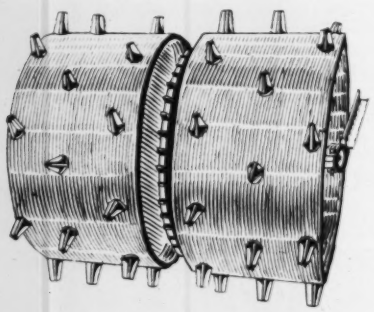


FIG. 3 THE REAR WHEELS OF THE WHITING-STANDARD TRACTOR

along a vertical axis the superimposed curves (different curves) and then drawing an averaging curve through them.

The area to be obstructed by the needle at different loads is the annular area between the full-load adiabatic and the adiabatic for the given load. The needle difference curves are plotted by radii, which radii are the radii of circles whose areas are those of the annular rings.

From the first part of this report one of the main conclusions of the investigation in regard to the flow of air through orifices was to the effect that a well-rounded short nozzle had as the highest coefficient of discharge the value of 0.98. Therefore a short nozzle designed by the adiabatic formula, following this type and using a needle whose shape was determined as previously stated, may be expected to have a high degree of flow efficiency. This remains for experimental determination.

In connection with the above investigation, a series of tests was run to determine by actual measurement the rate of discharge of steam through a sharp-edged orifice 0.203 in. in diameter and in a 0.125-in.-thick brass plate.

In the computation of the rate of discharge, the authors used Grashof's formula. The results of the tests are shown in Fig. 2, where the curve obtained in the present experiments is compared with those of Napier and Rateau. (*Thesis presented to the Department of Mechanical Engineering, Leland Stanford Jr. University*, 1916, *et*)

Automobiles

WHITING-STANDARD FARM TRACTOR

The essential feature of this tractor is the employment, instead of the usual driving wheels, of two broad-treaded rollers (3 ft. 9 in. diameter) which together make up considerably more than 4 ft. There is no differential on the shaft to which both rollers are keyed (Fig. 3) and by which both are driven. The drive is effected through a single strong chain from a simple form of gearing, with one speed forward and one backward.

With such an arrangement it would be very undesirable to have one roller on the land and the other in the furrow, and therefore when plowing the plow is hitched on so as to come well to the side.

The two front wheels are quite close together. In the steering gear a small bevel pinion on the end of the steering column turns the bevel pinion mounted on a vertical shaft. In addition to this another small bevel pinion mounted on the same vertical shaft as the bevel wheel is in mesh with a large-radius tooth quadrant keyed to the central column which forms the pivot upon which the short front axle turns. This multiplies the mechanical advantage of the bevel several times. With this gear the machine can be turned in a circle of 30 ft. diameter; in other words, on a 15 ft. headland. (*Motor Traction*, vol. 24, no. 620, January 17, 1917, pp. 41-42, 4 figs., *d*)

TRUCK-SPRING LUBRICATION

The Fageol truck, made by the Fageol Motor Company of Oakland, Cal., has a unique system of spring lubrication, shown in Fig. 4. The upper view shows the support for the rear end of the front spring. The frame bracket is hollow and can be filled with oil. A wick leads from the reservoir to the center of the upper shackle bolt. This is drilled out and bored with a cross-hole, allowing the oil to pass to the left-hand end, whence it goes down through a hole in the side of the shackle to the lower bolt, which is also drilled to carry the lubrication to the middle of the bushings.

The lower view shows the suspension for the front end of the rear springs, the section being a projection on the center line of the filler cap. At the bottom is the rear-end hanger for the rear spring, in which the wick lifts the oil from the reservoir to the upper bolt.

It is not stated how often the oil is to be replenished in the reservoirs, but this operation would not have to be performed except at fairly long intervals. (*The Automobile*, vol. 36, no 3, January 18, 1917, p. 185 illustr. *d*)

Conveying Machinery

BELT-CONVEYOR COAL-LOADING PLANT IN NEW SOUTH WALES.

Description of a large belt-conveyor coal-loading plant recently erected at Port Kembla, N. S. W., under the direction of the Department of Public Works of New South Wales.

The port of Kembla was designed to accommodate ocean-going ships. On the completion of the port the breakwaters will include an area of 335 acres, with an entrance 1000 ft. wide. The depth of water at the entrance will be 49 ft. and on the coaling jetty 25 to 34 ft. at low water. The distance

from the railway along which the coal arrives to the 25-ft. low-water-depth line is 355 ft., and it was decided to build a jetty at right angles to the shore and equip it with a belt-conveying plant.

Siding accommodation is provided at the shore end of the jetty for 500 trucks. The full cars approach the shore end of the jetty on an incline of 1 in 120, and when empty proceed via the remainder of the loop to the empty sidings. Although the feeding loop as it approaches the jetty is on an incline, it is found advisable to have the trucks coupled and controlled by a shunting engine when unloading, as by this method the trucks are more readily handled than if gravitated, owing to the time lost in stopping and starting. At the point of intersection of the feeder lines and jetty, and under the former, is

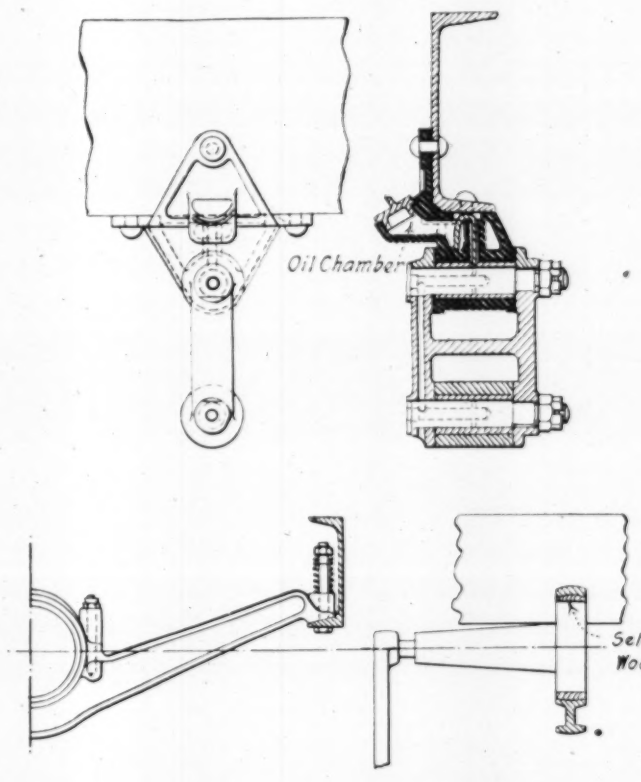


FIG. 4. ABOVE: DETAILS OF OIL-CONTAINING SPRING SHACKLES AND HANGERS USED ON FAGEOL TRUCK
BELOW: BEAM SUPPORTING FRONT END OF POWER PLANT. NOTE THE WOOD BUSHING USED

situated a steel bin of 35 tons capacity. The sides of this bin are sloping and are arranged so as to reduce the fall of coal from the trucks to a minimum. The trucks discharge on the upper portion of the sloping sides of the bin and not in the center, which minimizes the free drop of the coal and consequent breakage.

Because of lack of space, only the more unusual features of the design will be here reported.

The deck of the jetty is 8 ft. above high water of spring tides. The main conveyor belt is carried 3 ft. above the deck level of the jetty for 480 ft. from the shore, and at 580 ft. a driving station is constructed and the first section of belting ends. From this point the belt rises on a gradient of 1 in 5.5 on a light structure for a distance of 105 ft., and is continued on that level 22 ft. above the deck to the end of the jetty. While the jetty itself is of substantial construction, the framework carrying the main belts is of far lighter construction than would be necessary if trucks and locomotives were to be carried, and the gradients are much steeper than would have been practicable for loaded trucks. The fact that the coal can be lifted to the necessary elevation on this comparatively light structure is an important point in favor of economy in first cost of the plant as compared with an ordinary high-level jetty designed to carry trucks and locomotives. The further fact that the shore end of the jetty for a length of 534 ft. is only 18 ft. in width is also an economical feature in its construction, as, were it necessary to handle trucks on the jetty, a wider construction would have been necessary throughout. Each of the traveling arms is equipped with a conveyor belt which discharges the coal into a rectangular chute 3 ft. x 3 ft. x 34 ft. long, hung vertically between jaw ends at the end of the arm. Through this chute or loader the coal descends into the ship's hold. The loader has lateral play, and in addition can also be raised or lowered independently of the position of the loader arm by means of side pulleys moving in guides and operated by electric motor. The original intention in the design was that in order to minimize breakage of coal the loader should be kept as low as possible, indeed, practically in contact with the coal in the vessel, and be slowly raised as the loading proceeded. It was thought that in this manner the chute might be kept practically full of coal and actual dropping into the ship's hold be obviated. In practice, however, it was found impossible to regulate the operation of the chute with such nicety.

The great length (1400 ft.) from the flight-conveyor pit to the end of the jetty precluded the use of a single belt, and two belts are used. The short belt is 698 ft. in length, and the seaward belt 722 ft. between centers of tension pulleys. The first belt discharges onto the second over a gridiron chute, and each belt is operated at the forward or seaward end, the coal traveling toward the operating pulley. Although timber screens are provided on each side of the belt to protect the coal, they are not close enough to the belt to act as guides to keep the coal in place, nor are any such guides necessary, the troughing of the belt sufficing for that purpose.

The belts are 36 in. in width, with four-ply duck canvas in the center and seven-ply at the edges. The thickness of the rubber coating is $\frac{1}{16}$ in. on the back and $\frac{3}{16}$ in. in the center of the working face, the thickness of the rubber diminishing toward the edges of the belt as the number of the plies of duck increases. The canvas duck used in the manufacture of the belt was specified to withstand a tensile stress of 400 lb. on the lineal inch after vulcanizing. Each of the four rubber belts at present in use was manufactured in a continuous length, a course which was thought advisable at the time owing to the great difficulty of providing a satisfactory joint in the rubber belting. Mr. de Burgh, who designed the works, is, however, satisfied that this construction is not to be recommended. The task of getting the long belts into place, which necessitated the unshipping of the idlers and pulleys, was a very serious one, and the danger of a complete and prolonged interruption of the working of the plant following an accident to a portion of the belt is so great as to make it most desirable that jointed belts should be used. However, one of the loading-arm belts needing repairs has been cut out and a new belt jointed with so-called alligator steel clips has been introduced. If it proves satisfactory the like can be used in the main belts if required.

These rubber belts have been in operation since April 1915, and had up till the beginning of September last loaded 231,514 tons of coal and 47,635 tons of coke, and their condi-

tion was then excellent. Not only were immense lumps of coal delivered from the collieries, but pieces of broken machinery and even sleepers with dog spikes protruding from them came through the chutes. No serious damage, however, resulted from these causes, and, while small abrasions of the surface of the belt occurred, it has not yet been necessary to cut out a length of the main belt. To make surface repairs cheaply and rapidly, a small portable vulcanizing plant has been provided.

The conveyor belts are operated at a speed of 360 ft. per min. This speed may be increased to 500 ft. per min. by a simple alteration of the gearing, but it has been found that the speed of the plant was sufficient, particularly as the speed of coaling is controlled by the trimming time of the vessels. In the case of one vessel, S. S. *Winfield*, 5420 tons were loaded in a total working time of 27 hr. 40 min., giving a loading speed of 196 tons per hour. The actual working time of the conveyor was, however, 11 hr. 32 min., or 58 per cent of the total time, and the quantity of coal loaded per hour of running time was 467 tons. While loading this vessel, 178 cars containing approximately 10 tons each were discharged, sent on to the empty roads, and the contents loaded in 182 min. running time. Further, during an uninterrupted run of one hour with a single chute discharging into one hatch, 500 tons were loaded, and in a similar run of one hour with two chutes working into two hatches, 647 tons were loaded, which is a very high rate for loading.

The whole plant is electrically operated. The total cost of the Port Kembla jetty coal-loading machinery and power house, including the concrete foundations of the latter, also of flight-conveyor pit and in the belt subways, but excluding all railway lines in approach, may be taken at £83,000. (Paper read by E. M. de Burgh before the *Northern Engineering Society of New South Wales*, September 13, 1916, abstracted from a report in *The Engineer*, vol. 123, no. 3184, January 5, 1917, pp. 5-8, 5 figs. *d*)

Corrosion

A Method for Practical Elimination of Corrosion in Hot-Water-Supply Pipe, F. N. Speller

Discussion of a method for "fixation" of oxygen and carbon dioxide in water previous to the latter entering the pipes, and description of two experimental plants and of results obtained.

Two methods may be used for removing from water gases producing corrosion. One is, reducing the pressure of the heated water, and the other, keeping the hot water in contact with a large surface of iron under pressure for a sufficient length of time to remove and fix the oxygen and carbon dioxide. The latter method has been in use at two plants during the past year: the research laboratory and hospital building of the National Tube Company, McKeesport, Pa., and the Irene Kaufmann Settlement, Pittsburgh, Pa. It is claimed that both installations have demonstrated that the corrosion of iron or steel pipe can be arrested and practically eliminated by this process.

The Irene Kaufmann Settlement was built in 1910, using wrought iron and steel pipe for the hot- and cold-water lines with storage tanks and gas heaters. All the hot-water piping was showing signs of serious corrosion by 1915 and a number of pieces had to be replaced with brass pipe. Every week or two replacements and repairs had to be made, which constituted a source of serious inconvenience.

The experimental plant which was put into use in December, 1915, consisted of a storage tank filled with alternate pieces of corrugated and plain steel sheets No. 26 gage, arranged radially around the filter. The water was heated by a heater with a capacity of 3 gal. per min., and passed downward between these plates, being thereby deoxidized to a large extent. The water then flowed upwards through pipes to the top of the filter and downwards again through the filter and finally up through the central pipe to the system.

It is of course necessary before use to filter the fine rust out of water so treated, and it is also necessary that the filter be so designed in connection with the heater as to be kept hot when no water is being drawn. An illustration shows the course of the water circulating between the heater and storage tank, and the arrangement by means of which the temperature of the filter is maintained the same as that of the water in the storage.

For use as deoxidizers disks of Cambridge metal lath were placed. Strips of this or other suitable form of sheet iron may be used provided they are spaced so as to fill the chamber and yet leave a cellular structure with openings not over $\frac{1}{4}$ or $\frac{3}{8}$ in. through which the water can freely circulate. Steel turnings cannot be used because they get packed tight after a while. Rust occupies a space several times that of metallic iron and this must be provided for.

The average oxygen content of the water at the Irene Kaufmann Settlement before treatment was about 8 cc. per liter, and after treatment 0.5 cc. per liter. Since the treatment was installed, for nearly a year there has been no trouble with the old piping, even though it was in very bad shape at the time of the installation of the new plant.

Numerous corrosion tests were run by the Pittsburgh Testing Laboratory. Among other things it was found that there is no practical difference between the best grades of so-called "genuine" wrought-iron and steel pipe under the conditions of the test. These experiments also indicated that the water which had been in contact with the plates in the deoxidizer still carried considerable gas in solution, but this gas consisted mainly of hydrogen and nitrogen; in fact, the hydrogen frequently ran as high as 20 per cent.

From gas analyses and oxygen determinations made from time to time, it has been found that the rate of removal of oxygen has not diminished with length of service. Plates which were removed from the McKeesport plant after eight months' service had a thick layer of rust over the surface, but the efficiency of the tank was even greater after use. (*Journal of the American Society of Heating and Ventilating Engineers*, vol. 23, no. 9, January 1917, pp. 149-160, 6 figs. *e*)

Drying

Drying in Industrial Plants, J. O. Ross

Discussion of the fundamental principles underlying the design of drying systems.

It is generally true that as much drying out of the water should be done mechanically as is possible, by such means as pressing the material or by removing the water in centrifugals, as mechanical drying is cheaper than drying by heat. On material which would not be retained by the shell of a centrifugal, or which is not adaptable to the filter press, mechanical drying may be done in the settling tank. This system is in general use in the starch industry in Europe. The solid matter is allowed to settle to the bottom, and the water removed from the tank. In this way sludge forms on the bottom

containing about 50 to 60 per cent water, which is afterwards completely dried out in the heat driers.

As regards artificial drying, the simplest type is the one using direct application of heat, such as evaporating kettles to heat the material and vaporize the water. The next consists in placing the material in a heated room and allowing it to dry as best it may.

The design of driers is most essentially affected by the consideration of whether the drier should handle the material continuously or in batches. A progressive drier in which material moves gradually or continuously either on trucks or conveyors offers many advantages in cost of labor and economy of heat, as is well exemplified in the tunnel method of drying bricks. In addition to its economy, however, this method presents several other advantages. The wet "green" brick encounters only air which is comparatively cool and moist and it does not receive a harsh, quick surface drying which is so injurious. Another advantage is that each cubic foot of air is in intimate contact with the material throughout the entire length of the tunnel and picks up much more water than if it merely struck it and bounced off into space as it ordinarily would in a room drier.

There are, however, many cases when a progressive drier has drawbacks. This happens,

1 When the material comes from the machine in batches;
2 When the variety of the material differs widely in drying requirements;
3 When the material requires different treatment than a gradual increase in temperature and decrease in humidity of the air.

As regards the third condition, its importance grows as more study is given to the drying problem from the standpoint of quality of material.

As regards "apartment" driers, one of the main troubles connected with their operation can be overcome by decreasing the capacity of the compartments and increasing their number. The greater the number of compartments, the more nearly does an apartment drier approach the efficiency of a progressive drier. In lumber mills making products varying from 1 in. thick to 4 in. thick, an apartment drier presents many advantages, even if it is necessary to put the different thicknesses of material in the same compartment.

As a general rule, material which dries fast is more adaptable to a progressive drier than a material which dries slowly. Indeed, in extreme cases where the material requires a long drying, it would be found that a progressive system would travel so slowly as to be troublesome.

The entire efficiency of the drier usually depends on how intimate the contact is between the air and the material. From this point of view, a progressive drier is probably several times as efficient as drying in a room by simply blowing in warm air.

A very common type of drier of the simple order is the so-called bed or screen type. This usually consists of a horizontal screen on which loose material is thrown. Air is applied under pressure to the under side of the screen and forced up through the material, which usually means a very intimate contact and a very high efficiency. This method is applied to the drying of grain, scrap rubber, wool, cotton, and similar materials.

The cylindrical drier gives a very intimate contact between the drying medium and the material to be dried. In the more common type this consists of a round cylinder, usually on an incline. The material is fed in at one end and as the cylinder revolves the material is thrown around in such a way that it presents a large amount of surface to the warm air which passes through the cylinder. Baffles and paddles are placed inside so as to aid in this throwing, and the incline should be made such that the material will travel at a fixed rate of speed through the cylinder.

In general, in designing a drying system, considerable study should be given to the material and the drier designed in such a way that the warm air will come into the most intimate contact possible with the material. It should be borne in mind that there is a certain limit to the speed of drying of all material, and this limit should be determined. The writer has known materials that would dry in 40 hours in a very crude drier, but, even when placed in a first-class drier, would not dry in less than 36 hours. This is the big problem that an engineer encounters on a drying proposition—as to how long he may expect it to take to dry, as this determines the highest speed possible in the movement of the material. (*Journal of the American Society of Heating and Ventilating Engineers*, vol. 23, no. 2, January 1917, pp. 201-207, *g*)

Engineering Materials

An Investigation of the Brittleness Produced in Steel Springs by Electroplating, M. DeKay Thompson and C. N. Richardson

Several years ago Dr. W. H. Whitney called attention to the fact that small steel springs become brittle when plated in a copper-cyanide bath. The writer undertook to find the cause of this deterioration and to establish under what conditions it does and does not occur.

While no explanation of the brittleness produced in a spring wire when used as a cathode in a hot cyanide solution could be found, results of considerable interest were, nevertheless, obtained. These results are summarized by the authors as follows:

1 Spring steel becomes brittle when used as cathode in a hot cyanide solution, either sodium cuprocyanide or simply sodium cyanide. The effect is more pronounced with the simple salt. Brass and phosphor bronze are not affected.

2 Brittleness was not produced by the liberation of hydrogen on the steel.

3 The carbon content is not changed by electrolysis.

4 The crystalline structure is not changed by electrolysis

5 The brittleness is not produced in annealed wire.

6 The brittleness is produced by use as cathode whether the wire is coiled or not bent in any way.

7 The brittleness is not produced when the wire is used as anode or when it is suspended in the solution without the passage of electricity. (*Metallurgical and Chemical Engineering*, vol. 16, no. 2, January 15, 1916, pp. 83-84, *e*)

Cast Iron for Engine Cylinders, J. Edgar Hurst

The paper was divided into three sections, the first dealing with the wearing of cast iron, its structure, hardness and machining considerations. Section 2 was on growth and dealt with heat treatment of gray cast iron and the effect of heat treatment on engine pistons. Section 3 was devoted to the chemical constitution of the metal.

Under a given load and speed it would appear that wear in engine cylinders was proportional to the tensile strength of the iron. Cast iron of the highest tensile strength at normal temperatures was that having the closest-grained structure and the

free-carbon constituent existing in a very finely divided or, alternatively, in a rosette form. In so far as pure surface disintegration was concerned, the identity of the micro-constituents of cast iron is of little moment, but it becomes of importance in view of the effect of the action of alternating stresses on the character of the surface grains and the effect of the differential polishing of these grains.

With regard to hardness tests, the method of applying Brinell hardness numbers to cast iron in the case of engine cylinders is far from satisfactory. Cast irons giving the same hardness numerically often wore at widely different rates, and, furthermore, the influence of the presence of such elements as manganese and chromium, which in normal percentages were not detected by the hardness numeral, was most important.

There is a great amount of uncertainty in the definition of hardness and it is very doubtful whether the methods of determining hardness actually do determine this property in its entirety. The author states that in his opinion in a homogeneous material a true hardness property is its resistance to wear. From this, therefore, the resistance to wear becomes a function of the cohesion of the particles, or, rather, becomes the resistance to deformation, and therefore he suggests tentatively that the yield point is a more correct indication of the true hardness.

As regards cast iron, the author said it was extremely probable that wear due to surface disintegration was really a function of the brittleness of cast iron. The abrasion or relief polishing was the true wear, in that it depended upon the resistance to deformation of the individual component grains.

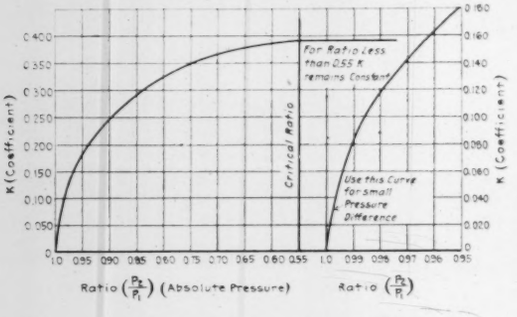

K (Coefficient)
For Ratio Less than 0.55 K remains Constant
Critical Ratio
Use this Curve for small Pressure Difference
Ratio $(\frac{P_2}{P_1})$ (Absolute Pressure)
Ratio $(\frac{P_2}{P_1})$

FIG. 5 CURVE OF K (COEFFICIENT) FOR FLOW OF NATURAL GAS THROUGH STANDARD ORIFICES

The temperature at which growth appeared to commence was about 650 deg. cent. and it reached a maximum at about 750 deg. cent. After prolonged heating, in addition to a gradual increase in volume a gradual increase in weight was also noted. The facts are established that:

1. Alloys not containing graphite do not grow.
2. Alloys containing graphite are, under suitable conditions, capable of growing; and, further, the total growth is roughly proportional to the silicon content.

In this connection the author discussed piston troubles with Diesel engines. He believes that the ultimate cracking of Diesel-engine piston tops could as a general rule be traced to the phosphorus content of the cast iron, and the cracking was practically eliminated when this was kept sufficiently low. Specimens taken from the center of a star crack in a piston showed liquation of the phosphide eutectic. This would undoubtedly increase the magnitude of the internal strains and, in addition, at points in the region of the center this same eutectic would at these temperatures be dangerously near its liquation point. Both phosphorus and silicon had a profound influence on the swelling out of the graphite plates. (Paper read before the *Manchester Association of Engineers,* December 9, 1916, abstracted through *The Engineer,* vol. 122, no. 3182, December 22, 1916, pp. 549-550, 1 fig. *te*)

Gas Engineering

MEASURING GASES BY A STANDARD ORIFICE

Prof. Thomas G. Estep, Jr., of the Carnegie Institute of Technology, gave the following formula for weight of gases discharged through an orifice in pounds per second:

$$W = \frac{A P_1 K}{\sqrt{T_1}}$$

where A = area of orifice in square inches; P_1 = pressure just ahead of the orifice, pounds per second absolute; K = coefficient from curve for flow of air through standard orifice, Fig. 5; and T_1 = initial temperature of gas, degrees fahrenheit absolute.

For K the paper gives a rather involved formula. H. G. Geissinger, in his article in Blast Furnace and Steel Plant for February, 1917, offers simplified expressions for the constant K. He gives the following as a general formula for determining the value of K corresponding to value of d less than the maximum from the characteristics of the gas expressed by the values of R and n as

$$W = \frac{A P' K}{\sqrt{T}}$$

where W is discharge in pounds per second; A = net area orifice in square inches; P' = pressure on orifice, pounds per square inch absolute; d, drop in pressure across orifice, pounds per square inch; T = absolute temperature of entering gas in degrees fahrenheit; n = ratio of specific heats, constant pressure to constant volume; R = a constant for the gas in question. As an example of the use of this formula, H. G. Geissinger offers the following:

Determine K for a drop ratio of $d = 0.25$ (pressure ratio 0.75), in natural gas, where $n = 1.27$ and $R = 4$. From this data we find:

$$r = \frac{64.3}{94} = 0.683$$

$$f = 1 - \frac{(1.4 - 1.27)}{10} = 1 - 0.013 = 0.987$$

$$\text{and } p = 0.55 + \frac{0.72}{1.27} = 0.55 + 0.565 = 1.115$$

Therefore,

$$K = \sqrt{0.675\ (0.25 - (1.115 \times 0.0625)} = \sqrt{0.122} = 0.35$$

(Composite abstract of a paper by Prof. Thomas G. Estep, Jr., in *Blast Furnace and Steel Plant*, vol. 5, no. 1, January 1917, pp. 16-18 and 31, 2 figs; and paper by H. G. Geissinger in *Blast Furnace and Steel Plant*, vol. 5, no. 2, February, 1917, pp. 55-56, *et*)

A METHOD OF DETERMINING THE DENSITY OF FLUE GASES, Jas. Alex. Smith

It is often desirable to ascertain the density of a gas without making a chemical analysis. In the present paper the writer describes a novel method for determining gas density by gage reading.

The basic theory on which this method is founded is that the densities of gases and their pressures per unit of area of bases are directly proportional when the gas columns are of equal height. Hence if a column of air in a vertical tube

of known height is displaced by a given gas, the barometric and thermometric conditions remaining constant, the densities are in the simple ratio

$$D = \frac{P \pm P'}{P}$$

where D = density of the given gas referred to air taken as unity; P = known air pressure due to column height; P' = difference ($\pm$) of pressure due to gaseous displacement.

In his apparatus shown in Fig. 6, the writer shows a two-liquid differential gage which he has previously described in another article. The gas tube is simply a piece of ⅛-in. wrought-iron gas barrel A, 100 in. in height. At the bottom two stopcocks, B and C, permit alternate connection to a gas source or to the gage E. To check diffusion, the passage through the latter cock should be reduced to a pinhole. At the top a third cock, D, opening into the air, permits the tube to be gas-flushed and filled, and when the main passage is closed, continues the connection by a minute by-pass large enough to preclude any possible barometric difference of pressure between the gas inside and the air outside the tube, yet so small that the diffusion is negligibly slow. The surface of the liquid in the gage system and the bottom of the gas tube must be approximately at the same level.

The writer describes the method of calibration and the required corrections. (*The Mechanical Engineer*, vol. 38, no. 988, December 29, 1916, pp. 509-510, 1 fig., *d*)

Machine Shop

GAS-HEATED AND OIL-FURNACE-HEATED RIVETS, William F. Croston

Though the fuel costs are greater and the time of run longer, the Newport News Shipbuilding & Dry Dock Company prefers the gas furnace for heating rivets over the oil-fired type formerly used.

A test was recently run to check the cost of operating by gas as against the oil furnace formerly in use. Four hundred pounds of rivets were heated in each furnace. These were heated by the oil furnace in 44 min. and by the gas furnace in 57 min. The cost of heating the rivets by oil, with oil at 6 cents per gal., was 52.5 cents. The cost of heating a similar amount of rivets in a gas furnace, with gas at 55 cents, was 53.6 cents.

The rivets heated in the gas furnace were far superior to those heated in the oil furnace, as there was practically no scale on them, while the oil-heated rivets in same cases were badly scaled.

It is claimed that the gas-heated rivets stay hot enough to drive longer than those heated in the oil furnace, which is explained by the fact that the gas-heated rivets are heated evenly all the way through, while those heated in the oil furnace are extremely hot on the outside but not hot in the center, and thus cool more quickly than the gas-heated rivets. (*Bulletin of the Southern Gas Association*, January 1917, abstracted through the *American Gas Engineering Journal*, vol. 106, no. 4/3072, January 20, 1917, p. 87, 1 fig., *dc*.)

Pumps

MOTOR DRIVE OF HYDRAULIC-ELEVATOR PUMPS, Charles J. Carlsen

Data on the use of electric power for operating elevator pumps in important Chicago buildings and in particular in Hillman's Department Store, covering a period of three years.

The building was provided with 13 elevators, nine being hydraulic passenger elevators in two banks, four in one and five in another, and four steam elevators, two for passenger service and two for freight.

The hydraulic elevators are provided with vertical cylinders and plunger equipment 13 in. in diameter and 30 ft. long, with a maximum lift of about 80 ft. and a speed of about 400 ft. per min.; cars are operated on about one-half minute schedule; maximum pressure on the hydraulic system is 160 lb.

The steam equipment used for operating elevators was a 14 x 22-in., 14 x 20-in. Burnham simplex compound pump; a 14 x 20-in., 9 x 18-in. duplex compound pump, and a 16 x 9 x 18-in. duplex simple pump. On test, these combined pumps as operated consumed from 120 to 160 lb. of steam per i.hp-hr.

In September, 1913, a contract was entered into for supplying steam to the adjacent Reliance Building for the operation of various steam-driven devices. The amount supplied under this contract reached about 25,000,000 lb. of steam per year, as measured by a St. John meter.

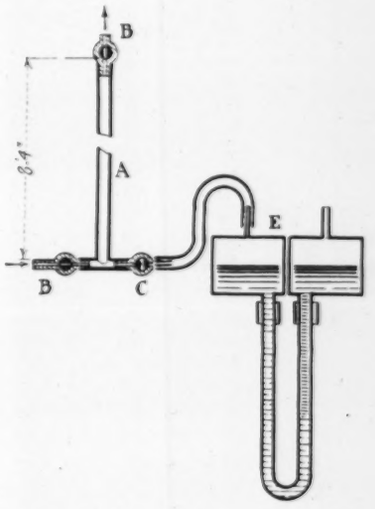


FIG. 6 TWO-LIQUID DIFFERENTIAL GAGE

All condensation excepting hot-water requirements is wasted to the sewer, there being no means provided for delivering these returns to the hot well of the boiler plant.

The bare cost for steam production per 1000 lb. based on a year's average and including only coal, ash removal, water for making and boiler compound, but not including any labor, maintenance or repairs, or overhead investments on plant, was found to be 24 cents per 1000 lb. with coal at $2.85 to $3.05 per ton. The writer gives the following figures to show the saving which he claims would be due to electric operation (Table 1).

This table is based on the assumption that a steam pump in fairly good condition will consume 120 lb. of steam per i.hp-hr., which is equivalent to 160 lb. per kw-hr.

In another office building, the Western Union Telegraph Building in Chicago, there was installed an equipment similar to that in the Hillman store, but using three three-stage, 350-gal.-per-min. Chicago Pump Company's turbine pumps, each direct-connected on a common subbase to a General Electric motor, and each controlled by a Cutler-Hammer control panel. Here the steam pumps are operated during the winter months

TABLE 1 HYDRAULIC-ELEVATOR OPERATION, SUMMER MONTHS

	1913	1914	1915
Estimated Steam Operation Cost.....	$4,732.03	6,094.08	5,575.30
Actual Electrical Operation Cost....	1,523.90	1,731.40	1,652.36
Annual Saving due to Electric Operation	$3,208.13	4,362.68	3,922.91

when exhaust steam is used for heating, but during the summer months the entire boiler plant is shut down and only a small boiler is run, of sufficient capacity to serve the building with the necessary hot-water requirements.

The article briefly mentions also other buildings in Chicago, St. Louis and New York City using motor-driven pumps in the operation of their hydraulic elevators. (*Electrical Review and Western Electrician*, vol. 69, no. 25, December 16, 1916, pp. 1046-1049, 4 figs. *cg*)

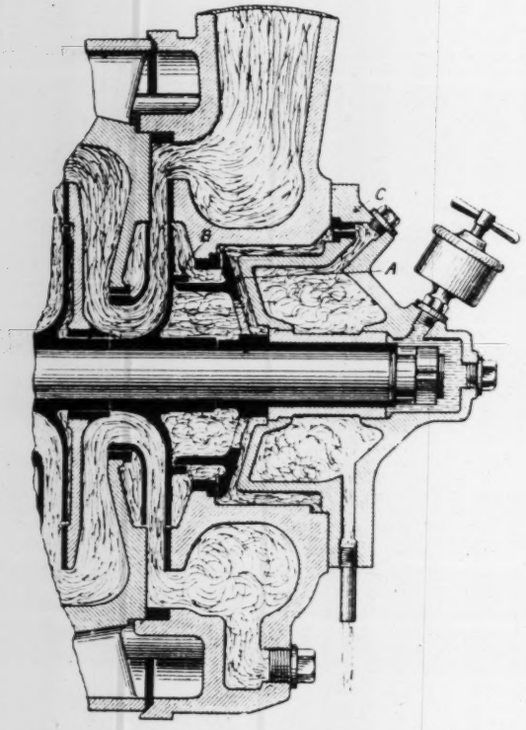


FIG. 7 AUTOMATIC HYDRAULIC BALANCING ARRANGEMENT FOR HIGH-LIFT CENTRIFUGAL PUMP

HIGH-LIFT CENTRIFUGAL PUMP

Description of a centrifugal high-lift pumping set recently built in England for delivering 200 gal. of water per min. against a total head of 1250 ft.

In designing the set the makers were restricted to the use of direct current for the electric-motor drive. Hence the speed of rotation was limited and the number of stages in the pump correspondingly increased. The difficulty was overcome by arranging two four-stage pumps in line and driving them by a common motor which runs at 1400 r.p.m.

The pumps work in series, each giving a head of 625 ft. The automatic hydraulic balancing arrangement shown in Fig. 7 enables the makers to dispense with thrust bearings. This is effected in the following manner: A valve *A* carried from the shaft by means of arms is so constructed that it fits into a ring *B* on the delivery side of the last impeller. The diameter of the ring is such that were there no hydraulic pressure on its inner area there would be an axial thrust towards the delivery end of the pump. The load necessary to balance the thrust on the impellers is taken on the back of the last impeller itself, as this forms one wall of the balancing chamber. The water required for balancing passes from the periphery of the last impeller to the balancing valve and thence to the balancing chamber, the outlet from which is controlled by the fixed orifice *B*. The latter connects with a drain. (*The Engineer*, vol. 122, no. 3182, December 22, 1916, p. 560, 2 figs., *d*.)

Railroad Engineering

EXPERIMENTAL REFRIGERATOR CARS, PENNSYLVANIA RAILROAD

The Pennsylvania Railroad has recently built at its Altoona shops two refrigerator cars to be used experimentally in milk-train service. The cars are essentially of all-steel construction.

In the design of these cars it was intended to utilize every means available, regardless of past practice, to provide a car that would furnish and maintain adequate refrigeration for milk and cream, either with ice placed in the ice bunkers or placed on top of the cans or boxes. Past experience indicated certain basic requirements enumerated in the original article.

The cars have trucks of special construction. The side frames are of cast steel. The side-frame center opening, the spring plank, and the wheelbase of 5 ft. 10 in. are the same as in freight trucks. The elliptical springs and bolster are the same as used on tenders. The axles are of the passenger type and the wheels are rolled steel, 33 in. in diameter. The journal boxes are pedestal-type passenger-car boxes. The truck, except for the bolster side motion, represents, therefore, a combination of passenger- and freight-truck features.

The end frame also combines passenger and freight principles. On the end sills and crossbearers oak blocks are placed to support the steel box forming the inside lining. The spaces between these blocks are filled with insulation consisting of four layers of ¾-in. Keystone hair felt, separated by wooden grids to form air spaces.

The inside lining consists of 3/16-in. floor plates, ⅛-in. side sheets and 3/32-in. ceiling sheets, all reinforced with U-shaped braces riveted to the outside. It forms a box which can be built up complete on the floor and then lifted to its proper location on the oak supports. A ¾-in. Keystone hair felt of as great width as can conveniently be manufactured and cut to the proper length is then lifted to the top of the lining box and unrolled to drop down the sides to meet and join the insulation under the floor. A continuous blanket is thus formed all around the inside box. There are four such blankets running transversely, separated with grids made of ½-in. strips of soft wood. Two additional layers separated with wooden grids are placed longitudinally on the top of the box and four layers are placed at the car ends to correspond with the sides. The Keystone hair felt consists of ¼-in. hair felt placed between two sheets of 90-lb.-specification paper and securely sewed together.

The sides, ends, and roof are also reinforced with U-shaped braces and are so designed that the riveting can all be done from the outside. This also permits removing a side, end, or roof for repairs without thereby disturbing any other part of the car.

No data are given as to the results obtained with these cars. (*Railway Review*, vol. 60, no. 5, February 3, 1917, pp. 155-157, 8 figs, *d*)

Refrigeration

Refrigeration and Refrigerator Insulation on Board Ship. Robert F. Massa

Paper discusses the construction and insulation of refrigerators "built in" on board ship.

Difficulty has been encountered with the use of cork that had not been sufficiently pressed previous to baking. This cork was not as dense as it should have been, and had not the mechanical strength it should have had.

As to refrigerator doors, the idea seems to prevail that they should have beveled edges and that such edges make a very tight door. The writer claims, however, that as soon as the moisture begins to have its effect, such a door cannot be tight any more. Further, if the hinges yield at all, as they are likely to do with such a heavy door, it will never be tight.

In the writer's opinion, the way to make a tight refrigerator door is to have a plain surface come up against a plain surface with a flexible gasket between them, or two pairs of such surfaces with gaskets between them, making an air pocket between the two sills. If this arrangement is used the door can sag considerably without causing any serious binding or failure in tightness.

As regards estimating the capacity of the refrigerating machine required to take care of the given refrigerator, it is not sufficient to calculate on heat loss through the insulation of the refrigerator, as it is only a part of the total loss. The other losses are due to heat entering in warm goods, by the interchange of air through the opening of doors, and by leaks through defective insulation or defective doors; to lights, or to the heat of the bodies of workers; to any change of state occurring in the goods, such as freezing, fermenting, etc. (Paper read at the Annual Meeting of the Society of Naval Architects and Marine Engineers, November 1916, abstracted from *International Marine Engineering*, vol. 21, no. 12, December 1916, pp. 546-547. *p*)

Steam Engineering

Forced Lubrication for Marine Turbines

With the more or less general adoption of geared turbines on all classes of ocean-going vessels, in most of which, unlike the Navy, there are only two engineers on watch, it has become necessary to give the subject of lubrication considerable thought with a view to obtaining a degree of simplicity and dependability which will reduce attention to a minimum. As every trade route has its own conditions, it is impossible to devise a system suitable for every class of ship, but the following system is claimed to meet the requirements of many single-screw cargo-carrying vessels in the ordinary trade routes.

A combined gravity and forced system offers the greatest advantages and consists simply of a pump taking oil from a drain tank and discharging it through a cooler to a gravity tank, from which it falls to the turbine bearings, etc., and back to the drain tank; or it can be by-passed, in which case it does not enter the gravity tank but is forced direct to the machinery.

The following main fittings would be required for such a system, and are stated in the order in which the oil would pass through them when traveling from the drain tank to the turbines: one drain tank; two oil strainers (one for each pump); two pumps, one working and one stand-by; one oil cooler; two gravity tanks; one combined oil distributor and water-and-sludge collector.

The drain tank should be of sufficient capacity when full to supply oil for fifteen minutes, assuming that none is returning to the drain tank. It should be a self-contained unit placed in a cofferdam in the double bottom rather than built into it, and should be easy of removal for examination. The top should be not less than six inches below the bottom of the gear case to insure a ready drain, and not less than three inches above the double-bottom tank to clear bilge water. In addition to the drain- and suction-pipe connections a float-level indicator can be fitted so as to be easily observed from the starting platform, also an air pipe and manhole.

The body of the oil strainer may be of cast iron, having a cover easy of removal. The straining grid may be a gun-metal casting or a steel tube perforated with holes, say, one inch in diameter, but in either case the area through the grid should be about ten times that of the suction pipe. A suitable straining medium is a 24-mesh wire gauze, which should be properly secured to the grid. The gauze will, however, reduce the effective area through the grid by about one-half.

The oil cooler may take the same form as a steam condenser, with similar tubes and packing, but with the water circulating around the outside of the tubes with preferably a four or six flow to insure good circulation. As, however, it is economically impossible to render the flow of oil turbulent, which makes the rate of heat transfer low, certain firms construct their coolers in a different way. The water is passed through the tubes, and the oil outside. Numerous baffles are fitted to cause the oil to flow up and down in zigzag fashion across the cooling tubes, and at each abrupt change in direction a certain disturbance is produced in the laminar flow of the oil, which facilitates the interchange of heat. At present, knowledge of oil coolers is in its infancy and there is much room for research and careful design. The present practice admits of oil discharging to turbines at 80 deg. fahr. and leaving them at a maximum of 120 deg. fahr.

The combined oil lubricator and water-and-sludge collector need be nothing more than a cylindrical casting of sufficient depth to admit of water and sludge gathering at the bottom while oil flows out at the top to the bearings and gear sprayers. It is desirable to fit separate connections from the distributor to the bearings and gear sprayers with a controlling valve at each, which facilitates adjustments whereby bearings and sprayers will each receive their proper share of the oil. A water draw-off cock placed about twelve inches from the bottom and a door for removal of sludge are to be provided.

The turbine pipes and fittings should be tested to 50 lb. per sq. in., with the exception of the tanks, for which a 5-lb. test is sufficient. A relief valve should be provided near the pump, set to blow off at 50 lb. per sq. in. and having an outlet led to the pump suction. (*Engineering*, vol. 103, no. 2662, January 5, 1917, p. 12, Editorial, *dp*)

Doust Joints

The Doust patent expansion joint (made in England) is entirely telescopic in its action and has neither gland, packing, nor rings. It has been standardized by the Board of Trade for steam working pressures up to 215 lb. per sq. in. and is approved by Lloyd's. It has two outer shells and two inner liners with flanges on the ends; bolts pass through the flanges of the pipes. With any alteration of length of range of pipes due to expansion or contraction they are free to work telescopically.

In addition to the original Doust joint which has four sleeves, a new joint has been developed with three sleeves

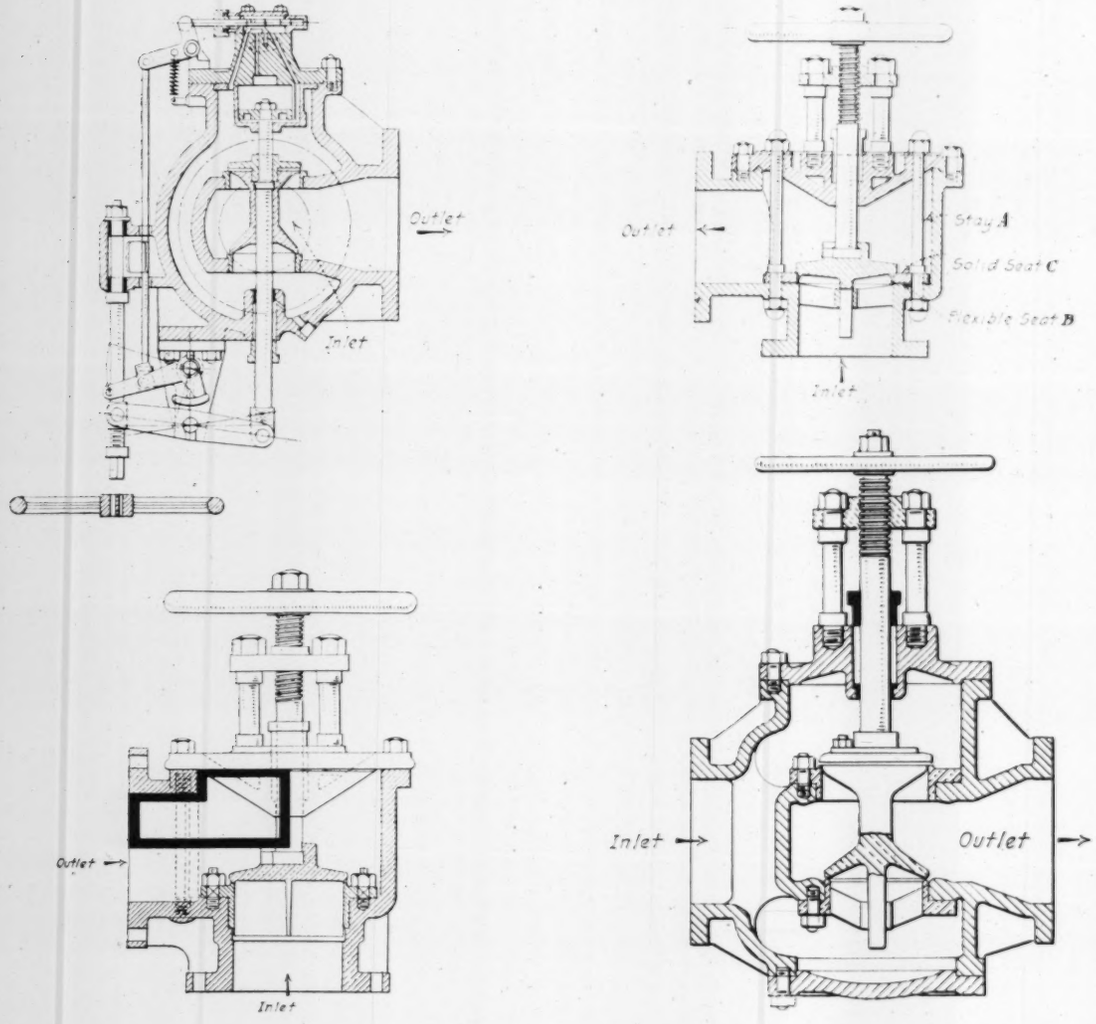
and is now under test to establish its suitability for steam. (*Steamship*, vol. 28, no. 331, January 1917, pp. 147-148, 2 figs. *d*)

THE DESIGN AND CONSTRUCTION OF HIGH-PRESSURE-STEAM STOP VALVES, D. Macnicoll

Description of the essentials of design and sources of trouble in high-pressure-steam stop valves.

Fig. 9 shows a type of single-beat unbalanced stop valve frequently used as a boiler stop. This is not a very good design, because of the unequal distribution of stresses. Assuming that the pressure is present throughout the chest and acting at right angles to the plane of section shown, the stress on the part marked *A* is much higher than on the other portions. The pressure on the portion outlined in black is approximately 8950 lb., which stresses the section on the top left-hand side to 1061 lb. per sq. in., whereas the average stress for the aggregate section is only 891 lb. It is true that the cover takes a portion of this stress, but this simply transfers the stress on to the studs and therefore does not improve the overall strength of the valve.

The stresses resulting from excessive hardening down are in many cases exceptionally high. In fact, if the valve lid did not give way in nearly every such case, there might be far more fatal accidents in this connection. In valves over 4 in. in diameter a flexible seating in conjunction with a solid face is of advantage, as with this arrangement leakage from distortion is obviated, and, in addition, there are two faces, so that if one is leaking from any cause outside of distortion, there is always the other one to fall back upon.



FIGS. 8-11 8, LEFT HAND, TOP: MODIFIED DOUBLE-BEAT VALVE FOR REGULATING PURPOSES IN RECIPROCATING WORK. 9, LEFT HAND, BOTTOM: SINGLE-BEAT UNBALANCED STOP VALVE USED AS A BOILER STOP. 10, RIGHT HAND, TOP: AN IMPROVEMENT ON THE LAST TYPE OF VALVE. 11, RIGHT HAND, BOTTOM: DOUBLE-BEAT-TYPE EXPERIMENTAL VALVE

Another source of high stress is when the valve has been shut down hard when cold and afterwards steam from other boilers is admitted to top portion of body. An actual experience of the author is illustrated in Fig. 10. This was a double-beat type of valve and the bottom seat was attached as shown. The valve was hardened down for steam test, with the result that after the test a number of manganese-bronze studs from the bottom seat were found lying broken in the bottom of the chest, and all showed signs of fracture caused by the expan-

sion of the spindle. One method of counteracting the damage from expansion is by fitting a spring crosshead. In Fig. 9 stays are sometimes fitted as indicated by the dotted lines. These only serve, however, to stiffen the cover and still further reduce the section of metal at an already weak section.

The rotation of the winged valves when steam is flowing is due either to a slight angle of the wings or to eddies in the steam. The valve can be prevented from rotating by means of a pin or otherwise. The damage done to valves from this rotation is hardly credible, and calls for the adoption generally of pintle- or center-guided valves.

Another source of trouble is the fracture of seat-securing pins or studs. In large sizes generally and in all sizes when superheated steam is present, seats driven in and secured by side pins become quite slack and allow leakage to occur. The seats in larger sizes are therefore secured in the manner shown in Fig. 9. The only way to avoid serious trouble with this design is to run a wire through the heads of all pins or through split-pin holes if studs are fitted. This prevents fractured portions being carried to some part where serious damage may be caused.

In Fig. 10 a type of valve is shown which is suggested as an improvement on that shown in Fig. 1. Attention is drawn to the method employed with a view to having the cover take up a measure of the bursting pressure which acts at right angles to the axis of the spindle. This consists of a tapered spigot on the chest with a corresponding tapered recess in the cover, making a metal-to-metal joint. The stresses from hardening down and expansion are mainly taken up by the four stays *A*, which also serve to secure the seatings. With this arrangement no loose parts are situated inside the chest, with the consequent prevention of damage from this source. The valve is centrally guided, thus preventing rotation. A flexible seat is shown at *B*, and when this and the corresponding valve face engage, the solid seat *C* and its corresponding valve face are 1/100 in. open, so that when this latter seat and face engage, the flexible seat is deflected 1/100 in.

Next is described a flexible disk to one of the beats of the solid double-beat valve, the purpose of which is to prevent leakage due to differences of expansion between the valve and the seat in the chest.

As regards double-beat types of valve used in reciprocating work for regulating purposes and as throttle valves, the writer states that in the future it is intended to make valves of the type shown in Fig. 8. Here a constant closing effort is present and will allow of perfect regulation under all circumstances and will not necessitate the adoption of saw-formation spigots on the beats. The slide valve is returned from position III to positions II and I by a spring assisted by the inlet pressure on the area of the slide-valve spindle where it passes through its stuffing box. Special types of ahead and astern double-beat regulating valves for turbine and reciprocating machinery are shown and described. (Paper read before the *Institute of Marine Engineers,* December 12, 1916, abstracted through the *Mechanical Engineer,* vol. 39, nos. 989-990, January 5 & 12, 1917, pp. 8-9 and 20-22, 13 figs, *d*. The original paper is not available.)

Thermodynamics

HEAT DENSITY, George P. Pearce

We hear a great deal about the B.t.u. value of fuels, that is, the B.t.u.'s of potential chemical energy contained in 1 lb. of various substances, but how many have considered the number of B.t.u.'s of heat there are in a cubic foot of space under various conditions? Let us assume 0 deg. fahr. as a base and see approximately what the heat density is for various conditions and substances. On a hot summer day, with the thermometer registering 110 deg., there seems to be plenty of heat everywhere, yet a simple calculation will show that there is only 1.8 B.t.u. to the cubic foot.

The gasoline blast torch is generally looked upon as a very hot flame, but in the hottest part of that flame the heat density is less than expected; it is 10 B.t.u per cu. ft. Hydrogen gas, with its enormous heat value, might be expected to make a better record than that, yet in the hottest part of a hydrogen flame burned in the air the B.t.u.'s per cu. ft. are just about 10.1; it has a heat density 1 per cent better than the gasoline flame in air. Not much is expected of carbon burned in air with its much lower heat value, so we are surprised when it shows a density of 12.3 B.t.u. per cu. ft. This, of course, is due to the greater density of the products of combustion. Incidentally, we note why coal is such a satisfactory source of heat for boilers; it develops a high heat density and thus rapidly heats the tubes; of course, other things enter into consideration as well. A great deal is said about acetylene, and it deserves credit, for this gas burned in air produces a heat density of 13.1 B.t.u. per cu. ft. So far the heat produced has been diluted by the presence of the inert gas nitrogen in the air. Eliminate this and burn acetylene in oxygen and a great change takes place, for now there are 24 B.t.u. in every cubic foot of the intense flame. Burn hydrogen in oxygen and there are 20 B.t.u. to the cubic foot.

It might be supposed that the limits for heated gases and vapors are being rapidly reached. However, ordinary steam just as it boils off water into the atmosphere contains 44 B.t.u. to the cubic foot. The oxy-acetylene flame takes a poor second place when compared with steam under these conditions. Some experimental high-pressure, high-efficiency, steam engines use superheated steam at 240 lb. per sq. in. and 300 deg. of superheat, and every cubic foot of this steam contains over 500 B. t. u. Strange as it may seem, saturated high-pressure steam at 235 lb. per sq. in. contains over 650 B.t.u. per cu. ft., and for carrying heat is superior in this respect to superheated steam. More astounding still is the humble cake of ice, which at 32 deg. is prepared to deliver 937 B.t.u. per cu. ft. when cooled down to zero. Boiling water is common enough, and as a heat container it holds over 12,000 B.t.u. per cu. ft.

Melted sulphur at 800 deg. fahr. has a heat density about twice that of boiling water, or over 22,000 B.t.u. to the cubic foot. Melted aluminum at 1214 deg. fahr. almost doubles this, with nearly 43,000 B.t.u. per cu. ft. Melted glass at 2377 deg. fahr. has nearly 75,000 B.t.u. in every cubic foot. Platinum, at 3300 deg. fahr., makes a big jump with its 182,200 B.t.u. per cu. ft. But common melted iron, at 2700 deg. fahr., leaves platinum away behind with 207,000 B.t.u. per cu. ft. However, they are all surpassed if a cubic foot of carbon is heated almost to its vaporizing temperature, say to 7000 deg. fahr., as a heat density of 700,000 B.t.u. per cu. ft. is then obtained. It is impossible for a person to look at this heated carbon or stand near it, and probably it represents the greatest heat density known. It is found in every arc lamp. Perhaps, when we obtain more data on this remarkable metal tungsten, which takes 5432 deg. fahr. to melt it and an unknown temperature to vaporize it, a still greater heat density may be had in melted tungsten just before it commences vaporizing. (Reprinted from *Machinery,* vol. 23, no. 6, February, 1917, p. 471-2, *g*)

THE DETERMINATION OF FREE ENERGY BY THE CLAUSIUS EQUATION OF STATE. E. Aries

For a body considered from the point of view of its molecular weight, the Clausius equation can be written as

$$P = \frac{RT}{v-\alpha} - \frac{\phi(T)}{(v+\beta)^2} \quad [1]$$

If the latter of the two constants is zero and the function ϕ is reduced to a constant K, the Van der Waals equation is obtained.

The above equation has a remarkable property which in the opinion of the author has not been perceived, in that it gives in a very simple manner an expression for the free energy I as a function of its usual variables, volume and temperature. We know that this energy expressed in this manner is one of the four Massieu functions, each of which is sufficient to determine all the properties of a body. We know that

$$-\left(\frac{\partial I}{\partial v}\right)_T = P = \frac{RT}{v-\alpha} - \frac{\phi(T)}{(v+\beta)^2} \quad [2]$$

from which, by integration with respect to v, we obtain

$$-I = RT \log (v-\alpha) + \frac{\phi(T)}{v+\beta} - \Phi \quad [3]$$

where ϕ is a function of the temperature introduced by the integration and may be determined from the theory of perfect gases.

If we assume that the volume v progressively increases at constant temperature, the body tends toward the state of a perfect gas, α becomes finally neglible as compared with v, and the equation [3] is reduced to the following (which is the equation given by the theory of perfect gases):

$$-I = RT \log v - \Phi \quad [4]$$

From this equation may be derived the following expressions, first, for the entropy S, and next for the molecular heat capacity at constant volume c (which constant is the same for all perfect gases of the same molecular complexity):

$$S = -\left(\frac{\partial I}{\partial T}\right)_v = R \log v - \frac{\delta\Phi}{\delta T}; \quad c = T\left(\frac{\partial S}{\partial T}\right)_v = -T\frac{\partial^2\Phi}{\partial T^2} \quad [5]$$

By double integration of the equation for c, one obtains

$$-\frac{\delta\Phi}{\delta T} = c \log AT; \quad -\Phi = cT \log AT - B \quad [6]$$

The value for ϕ thus obtained transferred into equation [3] completely determines the free energy of a body subject to the equation of state [1]. From this follow important consequences.

Equation [3] in its turn gives by derivation the following equations for entropy S and heat capacity at constant volume C_v:

$$S = -\left(\frac{\partial I}{\partial T}\right)_v = R \log (v-\alpha) + \frac{\frac{\partial\phi}{\partial T}}{v+\beta} + c \log AT$$

$$C_v = T\left(\frac{\partial S}{\partial T}\right)_v = \frac{T\frac{\partial^2\phi}{\partial T^2}}{v+\beta} + c \quad [7]$$

This expression for C_v would *a priori* indicate that the Van der Waals equation cannot agree with facts as observed. If ϕ reduces not only a constant but, what is more, to a linear function of temperature, then $\frac{\partial^2\phi}{\partial T^2}$ becomes zero, and C_v becomes constant, a conclusion clearly inacceptable except, perhaps, for monatomic bodies.

The application of equation [7] to the state of saturated fluids is of particular interest. If S_1, v_1 and S_2, v_2 represent the entropy and volume of a body in the state of a vapor and in the state of a liquid respectively, under tensions P and T, then the heat of vaporization of the liquid is equal to $T(S_1 - S_2)$, whence the following equation is derived, which indicates the heat of vaporization L:

$$\frac{L}{T} = S_1 - S_2 = R \log \frac{v_1-\alpha}{v_2-\alpha} + \frac{\partial\phi}{\partial T}\left(\frac{1}{v_1+\beta} - \frac{1}{v_2+\beta}\right) \quad [8]$$

v_1, v_2 and P are determined as functions of temperature by the three known relations

$$\frac{P}{(v_1-\alpha)(v_2-\alpha)-(\alpha+\beta)^2} = \frac{\phi T}{(v_1+\beta)^2(v_2+\beta)^2} = \frac{RT}{(v_1-\alpha)(v_2-\alpha)(v_1+v_2+2\beta)} \quad [9]$$

$$\frac{1}{v_1-v_2}\log\frac{v_1-\alpha}{v_2-\alpha} = \frac{(v_1-\alpha)(v_2-\alpha)(-\alpha+\beta)^2 + (v_1+\beta)(v_2+\beta)}{(v_1-\alpha)(v_2-\alpha)(v_1+v_2+2\beta)} \quad [10]$$

which unfortunately cannot be solved with respect to the unknowns v_1, v_2 and P. But Clausius has published a table which meets this difficulty in so far as equations of state of the type shown in [1] are concerned, by permitting them to be evaluated directly.

The author shows that equation [8] can be written as

$$\frac{L}{T} = R\lambda + \frac{1}{y}\frac{\partial\phi}{\partial T}\left(\frac{1}{y_1+1} - \frac{1}{y_2+1}\right) \quad [11]$$

and hence the heat of vaporization can be easily calculated for any given temperature by the Clausius table. The value of this temperature transferred into the first of the following three equations

$$x = \frac{27}{8}\frac{\gamma RT_c}{\alpha(T)}, \quad y = \frac{v-\alpha}{\gamma}, \quad z = \frac{8\gamma P}{RT} \quad [12]$$

giving x, and once the value of x is known the Clausius table will give all the other magnitudes.

If the function ϕ be replaced by a constant as in the Van der Waals equation, [11] takes the very simple form

$$L = \lambda R T \quad [13]$$

the value of λ being, according to the first of the equations [12], the one which corresponds to the reduced temperature $x = T/T_c$, so that it is only necessary to know the critical temperature T_c of a body in order to determine the heat of vaporization at any temperature.

The writer discusses the application of this equation to monatomic bodies but, because of lack of experimental data, comes to no definite conclusions (Sur la détermination de l'énergie libre par l'équation d'état de Clausius, E. Ariès. *Comptes Rendus des Séances de l'Académie des Sciences*, vol. 163, no. 24, December 11, 1916, pp. 737-741, t).

The report of the meeting of the Society of Automotive Engineers in the February issue of the Journal (p. 183) was written by John Younger, Mem.Am.Soc.M.E. By a regrettable error, his signature was omitted.

Motor Boat Show

The Thirteenth Annual Motor Boat Show was held under the auspices of the National Association of Engine and Boat Manufacturers in New York City, at the Grand Central Palace, from January 27 to February 3, 1917.

It did not show anything revolutionary in the way of either boats or engines, but was a good proof of the steady progress made in this line of engineering in the United States. As compared with the last year's show at the Grand Central Palace and the previous shows at Madison Square Garden, one was impressed by the apparent change from a trade which aimed mainly to serve the amateur and sportsman, to one which is apparently coming to rely on straight commercial work. The number of small engines exhibited was less than at any previous show, but there were many large engines, apparently intended for either large pleasure boats or heavy- and medium-duty commercial boats.

The general design of the engines also showed undoubted signs of improvement. In the majority of cases the workmanship is better, the wiring properly enclosed, magnetos take the place of dry-cell batteries and spark coils, more attention is paid to the balancing of the engine, and a decided improvement in the design of the lubricating system is noticeable.

Considerable attention was attracted at the show by the U. S. Navy patrol-type boats. These boats are about 45 ft. long and 10 ft. deep and have been indicated as a sample of what the U. S. Government would like yachtsmen to build as a combination yacht and patrol boat. One type exhibited at the show is powered with a pair of 150-hp. (each), six-cylinder, 6-in. x 6-in. Van Blerek motors, capable of driving the boat fully loaded at a speed of 25 mi. per hr. Her fuel capacity is about 500 gal., which gives her a cruising radius of 300 miles.

Two Duesenberg motors were shown, one for motorboat use and the other an aeronautical type. For the latter an output of 1 hp. per 3 lb. of overall weight is claimed.

An interesting type is the silent-valve Driggs marine engine, exhibited by the Driggs Ordnance Co., of New York City. Fig. 12 shows the valve employed in the 4-in. x 6-in. six-cylinder engine. The inlet and exhaust ports have many times the area of valve openings of poppet-valve motors of equal bore and stroke. The gas passages are comparatively unrestricted, as there are no sharp turns or sharp corners to retard the flow of gas. This helps to obtain not only a full charge on the intake stroke but also complete scavenging on the exhaust stroke. The valve shaft is driven by means of a gear from the time shaft. A steep-pitch adjusting screw engages in a thread in the valve. The valve driving spring forms the driving connection between the valve drive shaft and the valve. As the valve heats it expands and requires greater effort to drive it. This extra effort causes the valve shaft to advance angularly a fraction of a degree relatively to the valve against the action of the spring. In so doing the screw tends to screw out of the thread of the valve and move the valve upward in its tapered seat. The valve lifts only enough to make the driving effort normal. This effort is normal when clearance is such that there is a film of oil of almost infinitesimal thickness between the valve and its seat. The adjusting mechanism controls this gradually so that the oil film is maintained at a constant thickness.

A shallow-draft boat of the vacuum-tunnel type has been exhibited in model. In this boat the propeller does not project beneath the bottom of the boat, and the blades are therefore fully protected at all times. Above the propeller chamber and connecting with it is placed a standpipe or vacuum chamber. From the top of this standpipe the air is exhausted by a small vacuum pump, which needs only to be operated for a moment in order to fill the tunnel and vacuum chamber. Atmospheric pressure forces the water up, filling the tunnel or wheel chamber and the standpipe or vacuum chamber above it. This column of water can be raised and maintained at any desired height from a few inches up to about 28 ft., the limit of atmospheric pressure. For every foot that the water is raised over the wheel the propeller is given solid, hard water of substantially the same characteristics that it would have if the propeller were operating the same number of feet below the water level. No data were given out as to any tests of the efficiency of this type of boat.

First Pan-American Aeronautic Exposition

The First Pan-American Aeronautic Exposition was held in New York City, February 8-15, and represented broadly the great progress made in American aeronautical engineering since the day when Wilbur Wright flew the first heavier-than-air machine in the world at Kitty Hawk. The original Wright machine was included among the exhibits, and was fittingly located right opposite the entrance to the exhibition. So great has been the progress in the thirteen years which have elapsed since the historic day of its flight, however, that in many respects the machine would be taken for a freak nowadays. It is remarkable, however, that in the essentials of construction comparatively little progress has been made; the location of the engine, the arrangement of the planes, the system of control, the methods of balancing, are fundamentally the same in the machines of today as in the old Wright biplane. But a tremendous progress has been achieved in those engineering details which convert a rough experiment into a practical success, to which fact the exhibits of present types of machines testified.

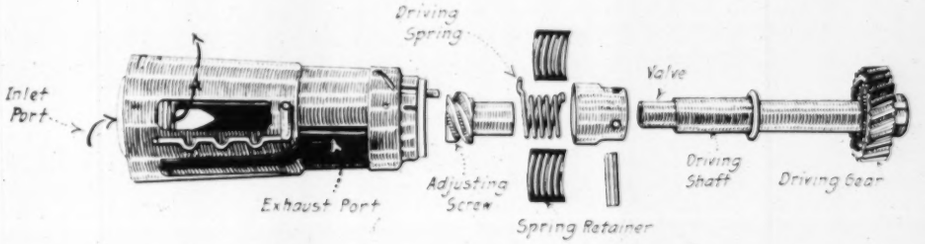


FIG. 12. RUSSELL SILENT VALVE FOR MARINE ENGINES

While the number of machines and engines exhibited was comparatively small, the quality of the products of American manufacturers was apparently as high as that of manufacturers in Europe, in so far as we are allowed to know of the progress there. It is true, however, that both the planes and the motors shown were smaller than what we understand to be the best European products of the same kind.

Very little was exhibited which was not known from previous published descriptions. A construction which attracted considerable attention was the aero-limousine at the stand of the Curtiss Aeroplane Corporation. This is a car

designed to run on the ground but also able to rise in the air. It is provided with small-diameter disk wheels or rubber tires and also aeroplane planes and controls. From an engineering point of view there is considerable doubt as to the practicability of the machine. No spring suspension is provided for the carriage and it is by no means clear how long such a vehicle would be able to run on the ground without having the motor shaken all to pieces. No provision is made for steering the vehicle on the ground; this, however, is not very important, because a considerable amount of steering can be carried out by means of the aero controls. No means for braking the vehicle on the ground are provided. From statements made in the press, however, it appears that this aero-limousine has been built for use in inspecting extensive sheep ranges in the West, which would indicate that the conditions of operation of the vehicle may be such as to make it possible to dispense with either high precision in steering on the ground or the necessity for braking.

The Aeromarine Plane & Motor Co. exhibited a new aluminum motor with cast-iron liners, a special distributor, and an electric starter weighing only 20 lb.

An apparent effort has been made to handle the exhaust from the engines in somewhat novel ways. The Witteman-Lewis machine proposes to deliver the exhaust downwards through the bottom plate of the engine. The L. W. F. Co. showed a machine in which the exhaust is delivered rearwards through two pipes about 4 in. in diameter and about 6 ft. long, bending downwards at about half length and then straightening out again and running along the sides of the fuselage. No attempt appears to have been made to provide any kind of a muffler for the machines.

On the whole, while no revolutionary inventions have been exhibited, the exposition shows a healthy state of development of the American aeronautical industry. No machines which could be used for heavy military work or long-range flying were exhibited, which does not, however, mean that American makers cannot build them.

SOCIETY OF AUTOMOTIVE ENGINEERS

In connection with the first Pan-American Aeronautic Exposition, the S.A.E. arranged on February 9 an aeronautic meeting, the first to be devoted entirely to the consideration of aeronautic-engineering subjects.

The morning session was devoted essentially to matters of standardization. The program comprised the reading and discussion of two papers, of which only one was actually read.

Jno. J. Rooney, of the Wright-Martin Aircraft Corporation, presented a paper (read by title) on Suggestions For Standard Tests of Aeroplanes. The matter of standard tests becomes of considerable importance in view of the fact that it appears that during the past year manufacturers have had considerable difficulty in obtaining with their machines the performance guaranteed to the Government in their contracts, a condition which in war time might become a national calamity.

In discussing this subject the author stated that it is the policy of some of the manufacturers to force successful performance regardless of the number of alterations in design required for the accomplishment, which the writer considers to be a grave mistake. As the testing field is usually at some distance from the factory and reliable records of engineering value are seldom kept on the field, the engineers often are deceived regarding the performance of the machine, especially as they are ignorant of changes that have been made in the machine to make it come up to expectations—changes often important enough to alter radically the original design.

The author suggests, therefore, the standardization of field tests. He proposes to use standard test forms for the aeroplane itself, the engine, propeller and for recording aeroplane data; and emphasizes the necessity of keeping track of the conditions under which machines are tested, with due regard to conditions under which they are to be flown.

The author comes to the conclusion that performance productions can be made more reliable by satisfactorily checking laboratory experiments with actual field tests, and advocates means for increasing the value of field tests.

The paper personally read by F. G. Diffin, of the Erie Specialty Co., Erie, Pa., on Standardization of Metal Parts for Aeronautic Use, told of some of the troubles of the manufacturer of metal fittings for aeroplanes and of some ways of minimizing if not entirely eliminating them.

The troubles of the part manufacturers are in the first place due to the multiplicity of the parts. Of screw-machine products alone on a well-known type of machine there are over three thousand separate parts. Many of these call for from two or three to as many as ten operations looking to their completion. Factories have today orders for one specific size of bolt for practically the same use on various makes of machines calling for the use of six different metals. They are asked also to make these bolts in over sixty different lengths, and practically the same condition exists in eight different diameters. It will thus be seen that should such specifications become general it would be necessary on hexagon-head bolts alone to manufacture 2880 separate items in order to fill aeroplane requirements. An additional bolt complication is the varying thickness of head called for by the different manufacturers. The same situation exists in rod and yoke-end points as well as in castle nuts.

This divergence in size and material called for creates troubles and delays not only for the manufacturer of parts but also for the aeroplane and engine manufacturer and user, and could the metal fittings become standardized the aeroplane manufacturer would find that the cost of many of these parts would be but a small fraction of the present cost.

In conclusion, the writer made specific recommendations for standardization, covering bolt dimensions and materials, rod and yoke-end points, and nut requirements.

In the discussion which followed an important difference between fittings for aircraft and automobiles was brought out, viz., that while in automobiles the matter of weight is practically entirely neglected and the matter of cost is preëminent (secondary of course only to that of safety), in the aeroplane, at least at present, the matter of weight is of greater importance than that of cost. Further, the shape of the fittings, which is scarcely considered at all in automobile construction, becomes of importance on aeroplanes as it affects unfavorably or otherwise the harmful air resistance of the machine. On the whole, however, all the discussors expressed themselves in favor of the adoption of some means towards the standardization of parts.

Henry Souther, Mem.Am.Soc.M.E., Chairman of the afternoon meeting, introduced the subject by a brief talk on the progress of aviation in this country and called attention to the urgent necessity of greater publicity for this new branch of locomotion. He called attention to the often neglected fact that actually a very large number of flights are made every day, flights of which not a mention appears in the papers.

On the other hand, the comparatively few mishaps and accidents are given wide publicity, with the result that in the minds of the public an entirely erroneous impression is created, both as to the state of the art and as to the work actually carried on.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

The Thirty-Third Annual Meeting of the American Society of Heating and Ventilating Engineers was held at the Engineering Societies Building, New York City, on January 16-18, 1917. J. Irvine Lyle was elected president.

An amendment to the constitution was offered by chapters to provide for chapters to be represented in the council, the representative to have no vote.

Of the reports presented the most interesting one was that of the committee appointed by the New York Chapter to consider a standard test for heating boilers. The purpose of this test is stated to be the determination of the capacity and efficiency of heating boilers under conditions approaching as nearly as possible those under which the boiler is to be installed. The specific object is the determination of the amount of steam which a boiler will furnish when burning a definite capacity of coal per hour in the manner for which it was designed. Therefore the schedule covering the report of tests will provide only for those items which are essential to determine the proper capacity of the boiler for commercial or sales purposes. No suggestions are made on this question of commercial rating or capacity except that as a basis of comparison the item "fuel available" should be calculated from area of firebox and depth to center of firedoor not exceeding 20 in. less 20 per cent for reserve; and item "time fuel available will last" figured on the basis of 8 hours.

The present report endorses the formula for calculating the rate given by the 1913 Committee in their report, in the following modified form:

Let C represent the pounds of fuel available for one firing period; let T represent the time fuel available will last; let E equal the total B.t.u. considered available per pound of fuel at boiler outlet, not exceeding results shown by tests.

Then CE/T represents the boiler capacity per hour in B.t.u. If rating is desired in equivalent square feet of direct radiation, divide the capacity in B.t.u. by 250 for steam and 150 for hot water.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The fifth annual mid-winter convention was held February 14-16 in the Engineering Societies Building, New York City.

The majority of the papers were on strictly electrical subjects, but in addition to these Major John H. Finney and Captain J. H. Cuntz read addresses on the part which engineers in general and electrical engineers in particular may take in military preparedness in its broad sense.

Professor R. A. Millikan of the University of Chicago read a paper on Modern Physics in which he spoke of the relations between physical research and electrical engineering.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p practical; s* statistical; *t* theoretical. Articles of especial merit are rated *A by the reviewer*. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

The Interisland Steam Navigation Company of Honolulu, is preparing to replace the old steam engine and boilers of its large passenger and freight steamer *Mikahala* with a single 320-hp. Type M Bolinder engine, which is equivalent in power to a steam engine of 440 indicated horsepower. (*Motorship*, December 1916)

A substitute for platinum, according to *The Ironmonger* (Jan. 27, 1917), is an alloy having the following percentage composition: copper, 6.42; manganese, 0.98; silicon, 1.04; tungsten, 2.13; nickel, 60.65; aluminum, 1.09; iron, 0.76; chromium, 21.07; molybdenum, 4.6. This alloy is said to have a high melting point and to be highly resistant to acids, making it capable of replacing platinum in many cases.

Castings of nichrome intended to withstand temperatures of from 1000 deg. fahr. up, without corroding, are covered by U. S. patent No. 1,190,652. The alloy contains 60 per cent of nickel, 26 per cent of iron, 12 per cent of chromium, and 15 per cent of manganese, the latter being incidental and not essential. If the carbon content is under 0.40 per cent, the alloy can be machined, rolled or forged. It is said to be suitable for valves and valve seats of internal-combustion engines.

John D. Northrop, of the United States Geological Survey, Department of the Interior, estimates that during the year just closed 292,300,000 barrels of crude petroleum was produced and marketed in the oil fields of this country. This quantity is greater by 11,000,000 barrels, or 4 per cent, than the output in 1915. In addition to the quantity of oil produced and marketed in 1916, several million barrels were produced and placed in temporary field storage in Kansas and Oklahoma.

Three 3000-kw. power plants are now operated by volcanic steam at Larderello, in Central Italy, according to *The Electrical World* (Dec. 23, 1916), and supply three-phase energy for transmission to Florence, Leghorn and many smaller cities. The natural steam, which is obtained from 12-in. to 20-in. pipes sunk from 300 to 500 ft. below the surface of the ground, is of a corrosive nature and is not used directly in the turbo-generators; instead, it is applied like fuel in specially constructed multitubular boilers, generating therein steam that after use in the turbo-generators is condensed and pumped back into the boilers.

In anticipation of the day when, on account of the advancing cost of gasoline and other products obtained from petroleum, it might be found commercially profitable to utilize some of the enormous supply of petroleum to be derived from the distillation of the vast deposits of so-called hydrocarbon shales of the Green River formation of northwestern Colorado and northeastern Utah, the U. S. Geological Survey has for three years been making field investigations of them.

Very rough but cautious calculations of the contents of the shale in parts of the area examined indicate that the distillation of shale from beds over 3 ft. thick in Colorado alone will yield more than 20,000,000,000 barrels of crude oil, from which more than 2,000,000,000 barrels of gasoline can be extracted by ordinary methods.

SELECTED TITLES OF ENGINEERING ARTICLES

AERONAUTICS

ZEPPELIN POWER PLANT ENGINEERING. Part I. The Automobile, vol. 36, no. 3, January 18, 1917, pp. 179-182, 11 figs.

NOTES ON SPEED INDICATORS FOR AIRPLANES. Winslow H. Herschel. Aviation and Aeronautical Engineering, vol. 1, no. 12, January 15, 1917, pp. 384-385, 1 fig.

THE LONGITUDINAL INITIAL MOTION AND FORCED OSCILLATIONS OF A DISTURBED AEROPLANE. S. Brodetsky. The Aeronautical Journal, vol. 20, no. 80, October-December, 1916, pp. 139-156.

FIRST REPORT OF AERONAUTIC DIVISION. S. A. E. Bulletin, vol. II, no. 4, January 1917, pp. 422-424, 3 figs.

† STANDARDIZATION OF METAL PARTS FOR AERONAUTIC USE. F. G. Diffin. S. A. E. Bulletin, vol. II, no. 4, January 1917, pp. 417-421.

AIR ENGINEERING

THE PHYSICAL PROPERTIES OF AIR IN RELATION TO PRACTICAL PROBLEMS. H. Eisert. Monthly Journal of the Engineers' Club of Baltimore, vol. 6, no. 8, February 1917, pp. 190-204.

NEED FOR HIGH AIR PRESSURES IN CONVERTERS. W. Trinks. The Blast Furnace and Steel Plant, vol. 5, no. 2, February 1917, pp. 53-54, 2 figs.

AUTOMOBILES

† THE WHITING-STANDARD FARM TRACTOR. MOTOR TRACTION, vol. 24, no. 620, January 17, 1917, pp. 41-42, 4 figs.

RETARDATION OF THE AUTOMOBILE. John Younger. S. A. E. Bulletin, vol. II, no. 4, January 1917, pp. 369-380, 2 figs.

HEAD-LAMP GLARE—WHAT IS IT? J. B. Replogle. S. A. E. Bulletin, vol. II, no. 4, January 1917, pp. 381-396.

VARIABLE-SPEED GEARS FOR MOTOR ROAD-VEHICLES. Robert E. Phillips. The Journal of the Institution of Mechanical Engineers, No. 1, January 1917, pp. 783-835, 28 figs.

† MAGAZINE OILING IN FAGEOL, A NEW CALIFORNIA TRUCK. The Commercial Vehicle, vol. 16, no. 1, February 1, 1917, pp. 22-23, 5 figs.

† UNIQUE FAGEOL TRUCK SPRING LUBRICATION. The Automobile, vol. 36, no. 3, January 18, 1917, p. 185, illustrated.

CERAMICS

THE DEVELOPMENTS OF THE CERAMIC INDUSTRIES IN THE UNITED STATES, A. V. Bleininger. Journal of the Franklin Institute, vol. 183, no. 2, February 1917, pp. 127-167, 22 figs.

CONVENTIONS

ANNUAL MEETING AND DINNER OF THE RAILWAY BUSINESS ASSOCIATION. Railway Review, vol. 60, no. 3, January 20, 1917, pp. 93-96.

THE IDAHO ENGINEER. Eighth Annual Convention, vol. I, no. 8, January 1917.

ANNUAL MEETING. Bulletin of The American Association of University Professors, vol. 3, no. 1, January 1917, pp. 5-7.

CONVEYING MACHINERY

BELT CONVEYOR COAL LOADING PLANT IN N. S. W. The Engineer, vol. 123, no. 3184, January 5, 1917, pp. 5-8, illustrated.

CORROSION

† A METHOD FOR PRACTICAL ELIMINATION OF CORROSION IN HOT WATER SUPPLY PIPE. F. N. Speller. Journal of the American Society of Heating & Ventilating Engineers, vol. 23, no. 2, January 1917, pp. 149-160, 6 figs.

DRYING

†DRYING IN INDUSTRIAL PLANTS. J. O. Ross. Journal of the American Society of Heating & Ventilating Engineers, vol. 23, no. 2, January 1917, pp. 201-207.

ARTIFICIAL DRYING, WITH SPECIAL REFERENCE TO THE USE OF GAS. Gilbert C. Shadwell. Journal of the Amer. Society of Heating & Ventilating Engineers, vol. 23, no. 2, January 1917, pp. 181-199, 13 figs.

ENGINEERING MATERIALS

ALUMINUM CASTINGS AND FORGINGS. P. E. McKinney. The Metal Industry, vol. 15, no. 2, February 1917, pp. 65-66.

† Abstracted in the Engineering Survey in this issue.

† AN INVESTIGATION OF THE BRITTLENESS PRODUCED IN STEEL SPRINGS BY ELECTROPLATING. M. DeKay Thompson and C. N. Richardson. Metallurgical & Chemical Engineering, vol. 16, no. 2, January 15, 1917, pp. 83-84.

SPUN GLASS AS PIPE COVERING. Mechanical World, vol. 61, no. 1567, January 12, 1917, p. 19.

ECROUISSAGE ET DILATABILITÉ DE L'INVAR. Ch. Ed. Guillaume. Comptes Rendus des Séances de L'Académie des Sciences, vol. 163, no. 24, December 11, 1916, pp. 741-744.
Cold working and expansion of invar.

MEMORANDUM ON TESTS OF HARDNESS AND RESISTANCE TO WEAR—Appendix I. W. Cawthorne Unwin. The Metal Industry, vol. 10, no. 27, January 5, 1917, pp. 6-9.

ESSAIS DE DIVERS SABLES POUR MORTIERS. M. R. Feret. Annales des Ponts et Chaussées, Series 9, Tome 34, vol. 4, July-August 1916, pp. 70-80.
Tests of various sands for use in mortars.

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SOME RELATIONS BETWEEN THE MAGNETIC AND THE MECHANICAL PROPERTIES OF STEEL AND OF NICKEL. S. R. Williams. Journal of The Cleveland Engineering Society, vol. 9, no. 4, January 1917, pp. 183-201, 10 figs.

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CAST-IRON: WITH SPECIAL REFERENCE TO ENGINE CYLINDERS. J. Edgar Hurst. Engineering, vol. 103, no. 2664, January 19, 1917, pp. 51-54, 9 figs.

A NEW BRAZING MATERIAL. Cassier's Engineering Monthly, vol. 51, no. 1, January 1917, pp. 75-76.

FUEL AND FIRING

COAL AND ITS ECONOMIC UTILISATION. John S. S. Brame. Journal of the Royal Society of Arts, vol. 65, no. 3346, January 5, 1917, pp. 136-143, 2 figs.

SAVING FUEL IN A LARGE INDUSTRIAL BOILER PLANT. David Moffat Myers. Industrial Management, vol. 52, no. 5, February 1917, pp. 639-650.
The author of this paper is known to our readers as an authority on power-plant practice. He describes the economies that were effected in a large, comparatively modern plant which is noted for the progressiveness of its management. Economies in such a plant, therefore, indicate to some degree what savings might be obtained in the average industrial plant. By no means the least important of the methods used was the establishment of a bonus system for firemen.

UEBER ROHÖLFEUERUNGEN IN HÜTTENWERKEN. Von Direktor L. Schweitzer. Stahl und Eisen, 36 Jahrgang, nr. 49, December 7, 1916, pp. 1174-1180, 13 figs.
Crude oil firing in metallurgical plants.

THE WATER CONTENT OF COAL, WITH SOME IDEAS ON THE GENESIS AND NATURE OF COAL. Edward Mack and G. A. Hulett. The American Journal of Science, vol. 43, no. 254, February, 1917, pp. 7-110, 10 figs.

COAL AND ITS ECONOMIC UTILISATION. John S. S. Brame. Journal of the Royal Society of Arts, vol. 65, no. 3348, January 19, 1917, pp. 163-172.

THE USE OF COKE AND COKE-BREEZE FOR STEAM GENERATION. John B. C. Kershaw. The Engineer, vol. 123, no. 3186, January 19, 1917, pp. 51-52.

FURNACES

VERTICAL FURNACE. Aeronautics, vol. 12, no. 170, January 17, 1917, p. 55, 1 fig.

GAS ENGINEERING

AN ORIGINAL DESIGN FOR A GAS VALVE. D. E. Keppelmann. The Gas Age, vol. 39, no. 3, February 1, 1917, pp. 121-123, 6 figs.

A STUDY OF THE THIN PLATE ORIFICE. V. R. Gage. The Sibley Journal of Engineering, vol. 31, no. 5, February 1917, pp. 120-124, 3 figs.

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HEATING AND VENTILATION

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Measures taken in 13 states to Insure Suitable Working Conditions in Factories.

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A Pelton Wheel. B. Wilding. The Model Engineer and Electrician, vol. 36, no. 820, January 11, 1917, pp. 17-18, 2 figs.

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Hydraulic Machinery at the Swiss National Exposition.

INTERNAL-COMBUSTION ENGINEERING

Will the Future Double-Acting Engine Be the Marine Diesel? Motorship, vol. 2, no. 1, January 1917, p. 9, 1 fig.

Piston Rods for High-Power Internal-Combustion Engines. The Mechanical Engineer, vol. 39, no. 990, January 12, 1917, p. 16, 4 figs.

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MACHINE DESIGN

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Reinforced Concrete Coaling Stations on the St. Louis-San Francisco Ry. Railway Review, vol. 60, no. 3, January 20, 1917, pp. 97-99, 4 figs.

Etude sur un nouveau système de pont suspendu rigide, G. Leinekugel Le Cocq. Le Génie Civil, vol. 70, no. 1, January 6, 1917, pp. 5-10, 6 figs.

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LIBRARY NOTES

From the Library of the United Engineering Society, Engineering Societies Building, New York. Includes Accessions to the Libraries of the Four Founder Societies

ACCORDING to an agreement made by the thoughtful kindness of Mr. Theodore N. Vail, such volumes of the large Dering collection of early books on electricity which he presented to the Massachusetts Institute of Technology several years ago as were found to be duplicated in their library have now been offered to the American Institute of Electrical Engineers as a gift. Such as are not already in the Institute's collections will be added to the Library.

The Library has acquired by purchase at auction an extensive collection of early works on technical subjects, especially the metallurgy of iron and steel, from the library of the late John B. Pearse. Mr. Pearse was associated with Alexander Holley and others in early steel manufacture, making the first Bessemer steel for rails in this country. Among the purchases was an edition in Latin of Pliny's "Historia Naturale," printed in Venice in 1489; John Webster's "Metallographia," London, 1671; Schonberg's "Ausfuehrliche Berginformation." Leipzig, 1693; Pomet's "Histoire Naturale des Drogues," Paris, 1694; Paracelsus' "Buecher und Schriften," Basle, 1589-91; John Muller's "Treatise of Artillery," Philadelphia, 1779; Libavius' "De Metallorum," Frankfort, 1599; Jacob Leupold's "Schauplatz des Grundes Mechanischer Wissenschaften" in nine volumes with copper plates, Leipzig, 1724-39; Beyer's "Theatrum Machinarum Molarum," Leipzig, 1735; and a large collection of works on varnish.

Reference lists on the following subjects have recently been compiled in the Library:

Bauxite and Aluminum Sulphate
Metric System
Mining in China
Wooden vs. Steel Water Pipe
Standardizing Rates of Pay
Disposal of Tailings by Electric Power
Electrolytic Zinc
Aluminum
Barium Chlorate
Street Traffic Regulation
Central Station Accounting
Household Refrigeration
Tumbling

Copies of these lists are available. The library is now compiling an extensive bibliography on nickel.

The process of moving the collections of the American Society of Civil Engineers to the United Engineering Society shelves has begun; several weeks must elapse before it is completed.

Few members of the Founder Societies seem to realize the facilities offered by the Library Service Bureau for making translations. Any article in any European language can be translated for members. German, French, Spanish, Italian, Swedish, Danish, Dutch, Russian, Bohemian, Servian and Japanese, can be covered by regular translators employed by the Service Bureau. The rates are lower than those charged elsewhere for technical translation.

W. P. C.

Am. Soc. M. E. Accessions

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CENTRIFUGAL FAN CALCULATIONS BY THE "SPECIFIC SPEED" METHOD. By M. C. Stuart. Reprinted from Journal of the American Society of Naval Engineers, Aug. 1916.

CENTRO NACIONAL DE INGENIEROS. Estatutos. *Buenos Aires, 1914.*

COMPARATIVE FRICTION TEST OF TWO TYPES OF COAL MINE CARS. By P. B. Liebermann. Reprinted from Bulletin, June, 1916, American Institute of Mining Engineers.

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LEAKAGE FROM PIPE JOINTS. By F. A. Barbour.

THE LIGHT REFLECTING VALUE OF SANITARY WALL PAINTS. Paint Manufacturers' Association of the U. S. Circular No. 43. *Philadelphia, 1916.* Gift of Paint Manufacturers' Association.

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NEW JERSEY PUBLIC UTILITY COMMISSIONERS. Statistics of Public Utilities, 1915. *Union Hill, N. J., 1916.* Gift of Public Utility Commissioners.

PUBLIC ENGINEERING AND HUMAN PROGRESS. By M. L. Cooke. Paper presented before the Cleveland Engineering Society, Nov. 14, 1916. Gift of C. W. Rice.

QUOTATIONS OF PUBLIC UTILITY SECURITIES, as of March 1, 1913, to assist in the preparation of Income Tax Reports together with full text of the Income Tax Law. Gift of Wm. P. Bonbright & Co.

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These tables of the properties of saturated and superheated ammonia are based partially on an experimental investigation carried out at the Massachusetts Institute of Technology. The experimental meth-

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Reducing Fuel Costs at the Schenectady Plant of the G. E. Co.

FLANNERY BOLT CO. Pittsburgh, Pa.
Staybolts. January 1917.

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Mack truck aids science.
Power dump trucks. (Catalogue 1A.)

LADD, G. T., CO. Pittsburgh, Pa.
Catalogue No. 17. Ladd water tube boiler

LEEDS & NORTHRUP CO. Philadelphia, Pa.
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This bulletin is issued as a step toward the promotion of standardized methods for both the casual measurement and continuous inspection of screw-cutting tools and their products. In theory, screw-cutting tools are supposed to reproduce their own threads. They do not always accomplish this in practice, largely because of the condition surrounding the application of power to them. Attention is therefore called to this fundamental idea, namely: it is not the tools that have to interchange, but the work done by them. W. P. C.

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THEORY OF THE FLEXURE AND STRENGTH OF RECTANGULAR FLAT PLATES APPLIED TO REINFORCE CONCRETE FLOOR SLABS. By H. T. Eddy. *Minneapolis, 1913.*

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——— Lectures on Electricity. *London, 1844.*

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SABINE, W. C. Students' Manual of a Laboratory Course in Physical Measurements. *Boston, 1893.*

SAWYER, W. E. Electric Lighting by Incandescence. Ed. 3. *New York, 1882.*

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GOLDSCHMIDT THERMIT COMPANY. *New York, N. Y.* Reactions. vol. 9, no. 3, 1916.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY. *East Pittsburgh, Pa.*
Catalogue 4-A. Westinghouse Distribution Transformers.
Catalogue 4-B. Westinghouse Feeder Voltage Regulators and Transformer Apparatus. *November 1916.*
Catalogue 7-A. Westinghouse Arc Lamps and Lighting Systems. *December 1916.*
Catalogue 7-B. Westinghouse Cooper Hewitt Mercury Rectifier Outfits. *December 1916.*
Catalogue 8-C. Westinghouse Electric Ware. *April 1916.*
Catalogue 8-D. Westinghouse Electric Ranges. *April 1916.*
Leaflet 1660. Automatic starters for Squirrel Cage Induction Motors.
Leaflet 1661. Automatic starters for wound rotor induction motors.
Leaflet 3668-B. Electric Arc Welding Equipments.
Leaflet 3814. Types CO and CR A. C. Relays.
Leaflet 3843. Auto starters for large squirrel cage induction motors.
Leaflet 3903. Alternating current grinder motors—Type CS.
Leaflet 3927. Feeder Voltage Regulators.

D. L. 3555 A. Westinghouse self-contained vertical shaft A. C. Generators.

SPECIAL PUBLICATION No. 1574. Maintenance of Equipment Harvard Shops Cleveland Railway Co. *October 1916.*

WHITE FUEL OIL ENGINEERING CORPORATION. *New York, N. Y.* Low Pressure Mechanical Oil Burning System. *1916.*

CEMENT GUN CONSTRUCTION COMPANY. *Chicago, Ill.* Bulletin no. 5. Gun crete for protection. Illustrations of Gun-crete work.

DE LAVAL STEAM TURBINE CO. *Trenton, N. J.* Catalog "B." High Efficiency Centrifugal Pumps.

LEHIGH CAR, WHEEL & AXLE WORKS. *Catasauqua, Pa.* Catalogue 50. Fuller Quality Products. Price list covering face hardened sprocket and traction wheels. *1915.*
70. Fuller Lehigh Pulverizer Mill. *1915.*
71. Pulverized coal equipment. *1916.*

PERSONALS

IN these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by March 15 in order to appear in the April issue.

CHANGES OF POSITION

JOHN O. HEINZE, until recently identified with the John O. Heinze Company, Springfield, O., has become associated with The Simms Magneto Company, East Orange, N. J.

WILBUR C. PRIOR, formerly chief draftsman of The Merrow Machine Company, Hartford, Conn., has accepted a similar position with Eaton, Crane and Pike Company of Pittsfield, Mass.

ROYCE L. BEERS, until recently assistant fuel engineer with the U. S. Bureau of Mines, Pittsburgh, Pa., has become associated with the U. S. Radiator Corporation, of Detroit, Mich.

ALFRED D. WHITE has entered the employ of the Illinois Stoker Company, Alton, Ill. He was until recently district engineer of the Green Engineering Company, with offices in Denver, Colo.

WILLIAM B. CORBETT, designer with the Terry Steam Turbine Company, Hartford, Conn., has become affiliated with the General Electric Company, Lynn, Mass., in the capacity of draftsman.

ARMIN S. HOFFMAN, formerly assistant engineer with The Texas Company, New York, N. Y., has become affiliated with the engineering department of the Griscom Russell Company, New York, N. Y.

HAROLD S. LORD has accepted a position with the Ruggles Machine Company, Poultney, Vt. He was until recently connected with the General Electric Company, Lynn, Mass., as mechanical engineer.

HENRY E. EAGAN, until recently manager of the Atlantic Ice and Coal Corporation, Dublin, Ga., has assumed the duties of chief engineer of the Harris Granite Quarries Company, Salisbury, N. C.

E. NESDAHL, formerly air-conditioning engineer with Warren Webster and Company, Camden, N. J., has become associated with the Braemes Air Conditioning Corporation of Philadelphia, Pa., in a similar capacity.

F. WM. HEISLER, formerly general foreman of the fuse loading department of the Newton Manufacturing Company, Lowell, Mass., has accepted a position with the American Locomotive Company, Schenectady, N. Y.

FORREST W. MANKER, until recently associated with the B. F. Sturtevant Company, Cleveland, O., in the capacity of district manager, has become identified with the American Incandescent Heat Company, Boston, Mass.

FRANK J. MCCARTY has become identified with the Rudel-Belnap Machinery Company, Ltd., Montreal, Canada. He was until recently in the employ of Tate, Jones and Company, Inc., Pittsburgh, Pa., as designing engineer.

D. WALTER MUNN, formerly with the Montreal Rolling Mills Branch of the Steel Company of Canada, has become affiliated with the engineering department of the Algoma Steel Corporation, Ltd., Sault Ste. Marie, Canada.

MYRON W. RICE, who was until recently in the employ of the American Engineering Company, Philadelphia, Pa., in the capacity of testing engineer, has become identified with the Columbia Chemical Company, of Barberton, O.

ALBION R. DAVIS has joined the staff of the Stone and Webster Engineering Corporation, Boston, Mass., as mechanical engineer. Mr. Davis was formerly connected with Gray and Davis, Inc., in the capacity of chief draftsman.

JOHN AIREY, assistant professor of engineering mechanics at the University of Michigan, Ann Arbor, Mich., has accepted the position

of inspector of munitions for the British Government, with headquarters at Chicago, Ill.

KENNETH WHITE, for the past seven years chief engineer of the By-Products Coke Corporation, Chicago, Ill., has assumed the duties of conveying-belt engineer of the Manhattan Rubber Manufacturing Company, Passaic, N. J.

THOMAS F. GITHENS, until recently in the employ of the American Synthetic Dyes, Inc., Newark, N. J., as assistant master mechanic, has become affiliated with the designing department of The Chile Exploration Company, New York.

L. C. WELCH, for five years division superintendent of the Cygnet Division of The Buckeye Pipe Line Company at Cleveland and Lima, O., has resigned to accept a position with the Mid-West Refining Company at Casper, Wyoming.

CLAUDE M. GARLAND, formerly mechanical engineer with Woodman-see and Davidson, Chicago, Ill., has been placed in charge of the newly organized power department of the Allen and Garcia Company, with headquarters in Chicago, Ill.

A. L. ROBERTS has resigned his position as designing engineer with The Crown Cork and Seal Company, Baltimore, Md., and has accepted a similar position in the construction department of the Bethlehem Steel Company, South Bethlehem, Pa.

RALPH C. CHESTNUTT has become associated with the engineering department of the Willys-Overland Company, Toledo, O. He was formerly connected with the Maxwell Motor Compaany, Inc., Detroit, Mich., in the capacity of layout draftsman.

JOSEPH E. SHEEDY has assumed the duties of assistant to the president of the Seattle Construction and Dry Dock Company, Seattle, Wash. He was formerly general superintendent of the Inter Island Steam Navigation Company, Ltd., Honolulu, Hawaii.

HARRY H. BATES, recently connected with the Norfolk and Western Railway Company, Bramwell, West Va., as power director, has accepted the position of assistant boiler superintendent of the Hopewell, Va., works of the E. I. duPont de Nemours and Company.

R. K. STOCKWELL, who has been chief engineer and superintendent for the Braden Copper Company, of Rancagua, Chile, for the past five years, has opened an office in Salt Lake City, as engineering and sales representative of the Robins Conveying Belt Company.

ERIC H. PETERSON, formerly mechanical and refrigerating engineer with the Ford Motor Company, Detroit, Mich., has assumed the duties of chief engineer with the Vogt Brothers Manufacturing Company, formerly the National Foundry and Machine Company, of Louisville, Ky.

DR. W. F. M. GOSS, Past-President, Am.Soc.M.E., dean of the College of Engineering of the University of Illinois, has resigned to accept the presidency of the Railway Car Manufacturers' Association, of New York. The resignation will take effect as soon as Dr. Goss can be relieved.

W. H. MARSHALL, formerly president of the American Locomotive Company, is to become associated with J. P. Morgan and Company. It is understood that recognition of the successful execution of munition contracts by the American Locomotive Company during Mr. Marshall's administration has led to his new connection.

PAUL H. LANGE, for the last 6½ years chief engineer of the Niagara Machine and Tool Works, Buffalo, N. Y., formerly chief engineer of The Toledo Machine and Tool Company, Toledo, O., is now connected with the Max Ams Machine Company, Bridgeport, Conn., as engineer and manager of their press manufacturing department.

ANNOUNCEMENTS

WALTER B. GUMP has joined the staff of Armour and Company, Chicago, Ill., as mechanical engineer.

MAX FRIEDLANDER has become associated with the American Radiator Company, Institute for Thermal Research, Buffalo, N. Y.

FRED W. TEELE was elected vice-president and managing director of the Southern Canada Power Company, Montreal, Canada.

J. A. MALONE, until recently connected with the New York office of the Allied Machinery Company of America, is now with the Paris office of the firm.

SANFORD E. THOMPSON announces the formation of a partnership with William O. Lichtner under the name of Thompson and Lichtner, with offices in Boston, Mass.

STANLEY D. WINGER, sales engineer with The Prest-O-Lite Company, Inc., Chicago, Ill., has been placed in charge of the newly organized railway sales and service department of the company, with headquarters in Indianapolis, Ind.

WM. A. CATTELL, HENRY S. HOWARD and RAYMOND ASHTON announce their association under the firm name of Cattell, Howard and Ashton, Engineers, San Francisco, Cal.

NORMAN W. STORER, general engineer of the Westinghouse Electric and Manufacturing Company, was elected president of the Veteran Employees' Association of that company.

ELLIOTT H. WHITLOCK has been recommended by the Chief of Engineers of the War Department for commission in the grade of Major in the Engineer Officers Reserve Corps.

A. L. HUMPHREY, first vice-president and general manager of the Westinghouse Air Brake Company, Pittsburgh, Pa., has been elected president of the Union Switch and Signal Company, in accordance with merger proceedings of the two companies. Hereafter he will assume the executive work of the two companies.

S. J. GATES, until recently commercial engineer with The Milwaukee Electric Light Company, Milwaukee, Wis., announces the organization of the Gates Engineering Company, commercial engineers. This company is prepared to investigate problems involving the supply of power, the development of new and additional business for municipally or privately owned electric and heating plants, the prospecting of new territory for electric power development, etc.

CHARLES R. COURTENEY and ROBERT E. CAHILL, chief draftsman and superintendent, respectively, with the Watertown Engine Company and later with the New York Engine Company, have formed a partnership and will conduct business under the name of the Watertown Engine and Machine Company. The company will make a specialty of repairs and replacements to Watertown engines and boilers, and in addition will do engineering work along the line of testing and adjusting power-plant apparatus.

APPOINTMENTS.

WARREN D. LEWIS has accepted an appointment as chief engineer of the Bradstreet Realty Corporation, New York, N. Y.

WILLIAM J. BAILEY has been appointed eastern sales manager of the United Coal Corporation, with headquarters in the Pennsylvania Building, Philadelphia, Pa.

WILLIAM RALPH WEBSTER has been appointed assistant chief engineer of the Cambria Steel Company, Johnstown, Pa. He was formerly chief draftsman of the company.

E. P. ROBERTS, consulting engineer, formerly Smoke Commissioner of Cleveland, O., has been appointed efficiency engineer of the Philadelphia Rubber Works Company, Akron, O.

ELMER F. BACKER, formerly in charge of the new designs and experimental work at the Davenport Locomotive Works, Davenport, Ia., has been appointed chief draftsman of the company.

AUTHORS

CHARLES M. HORTON is writing a series of articles on the Drafting Room for the *American Machinist*.

F. H. NEWELL addressed the February 1 meeting of the Engineers' Club of Trenton on Engineering Coöperation.

ALBERT A. CARY has contributed an article on Formation of Clinkers in Boiler Furnaces to the February 10 issue of the *Electrical World*.

F. A. HALSEY has contributed an article on Metric System in Engineering to the February 1 issue of the *American Machinist*.

FRANK RICHARDS is the author of Drill-Sharpening Methods at the United Verde Mine, Arizona, which appears in the February 1 number of *Engineering News*.

CARL G. BARTH is the author of Time Studies for Rate Setting as Originated by Dr. F. W. Taylor, which appears in the February 1 issue of the *American Machinist*.

DWIGHT V. MERRICK has contributed an article entitled Object and Method of Taking Time Studies for Rate Setting to the February 8 issue of the *American Machinist*.

WALTER RAUTENSTRAUCH is the author of Critical Speeds of Rotors Resting on Three Bearings, which is published in the February 1 number of the *American Machinist*.

THE NEW BOOKS

ALL books received by The Journal will be listed under this heading, generally accompanied by brief descriptive notes. Works of special importance to mechanical engineers will be commented on at length by members and others peculiarly qualified by reason of their experience and training. In this issue the list has been enlarged to include the chief publications brought out in the late summer and autumn of 1916.

AUTOMOBILES

Modern Starting, Lighting and Ignition Systems. By Victor W. Page. 5½ x 8 in., 509 pp., 295 illustrations. The Norman W. Henley Publishing Co., New York. $1.50.

BUILDING CONSTRUCTION AND EQUIPMENT

Mechanical Equipment of Buildings. By Louis A. Harding and Arthur C. Willard. Vol. I, Heating and Ventilation of Buildings. 7 x 9¼ in., 621 pp., illustrated. John Wiley & Sons, Inc., New York. $4. (To be reviewed later.)

Practical Safety Methods and Devices. By George A. Cowee. 5½ x 9 in., 434 pp., 128 illustrations. D. Van Nostrand Co., New York. $3. (To be reviewed later.)

Safety Engineering Applied to Scaffolds. 6 x 9 in., 339 pp., 127 illustrations. The Travelers Insurance Co., Hartford, Conn. $3.

ELECTRICAL ENGINEERING

A Laboratory Course of Practical Electricity. By Maurice J. Archbold. 7½ x 9¾ in., 211 pp., 98 illustrations. The Macmillan Co., New York. $1.10.

This book is made up of about one hundred loose-leaf blanks upon which to report the results of the experiments outlined therein, and is designed to be used in connection with any text-book. The experiments are intended to form four semesters of laboratory work, and, beginning with those on simple magnetic laws, range up through battery connections, resistance measurements, etc., to tests and measurements on d.c. and a.c. motors and generators and accessory apparatus. Diagrams showing the arrangement and connections of apparatus in the various experiments are given in an appendix.

Handbook of Machine Shop Electricity. By C. E. Clewell. 4 x 7 in., 461 pp., 315 illustrations. McGraw-Hill Book Co., New York. $3.

HOISTING AND CONVEYING

Elevators. By John J. Jallings. 5½ x 8½ in., 200 pp., 217 illustrations. American Technical Society, Chicago, Ill. $1.50.

MACHINE ELEMENTS

Elementary Cams. By Franklin DeR. Furman. 5½ x 9 in., 87 pp., 69 illustrations. John Wiley & Sons, Inc., New York, $1.25.

The author first describes the various types of cams in common use, and then defines the terms employed in the solution of design problems. Following this come explanations of the methods of constructing the several generally used base curves for unit rise of the follower. In the third section, which comprises over half the book, the advantages of designing on a scientific basis instead of by cut-and-try methods are set forth, and illustrative problems are worked out in detail for each of the types dealt with earlier. Short sections on the timing and interference of multi-cam arrangements and on cam mechanisms for reproducing given curves and figures are also included.

Empirical Design. By Leslie D. Hayes. 6 x 9 in., 99 pp., 66 illustrations. Carpenter & Co., Ithaca, N. Y. $1.

Power Transmission by Leather Belting. By Robert T. Kent. 5¼ x 8 in., 120 pp., illustrated. John Wiley & Sons, Inc., New York. $1.25.

Valves and Valve Gears. By Franklin DeR. Furman. Second edition. 6 x 9 in., 253 pp., 237 illustrations. John Wiley & Sons, Inc., New York. $2.50.

MACHINE-SHOP PRACTICE—METAL WORKING

Automatic Screw Machines. By Douglas T. Hamilton and Franklin D. Jones. 6 x 9 in., 342 pp., 150 illustrations. Industrial Press, New York. $2.50. (Reviewed in this issue.)

English and American Tool Builders. By Joseph W. Roe. 6 x 9 in., 315 pp., 58 illustrations. Yale University Press, New Haven, Conn. $3. (To be reviewed later.)

Forging of Iron and Steel. By Wm. A. Richards. 5 x 8 in., 213 pp., 237 illustrations. D. Van Nostrand Co., New York. $1.50.

Grinding Machinery. By James J. Guest. 5½ x 8½ in., 440 pp. Longmans, Green & Co., New York. $4.

Lathe Design, Construction and Operation. By Oscar E. Perrigo. Revised edition. 6 x 9 in., 460 pp., 341 illustrations. The Norman W. Henley Publishing Co., New York. $2.50.

Oxy-Acetylene Welding. By S. W. Miller. 6 x 9 in., 287 pp., 192 illustrations. Industrial Press, New York. $2.50. (To be reviewed later.)

Plain and Ornamental Forging. By Ernst Schwarzkopf. 5¼ x 8 in., 264 pp., 400 illustrations. John Wiley & Sons, Inc., New York. $1.50.

Practical Forging and Art Smithing. By Thomas F. Googerty. 5 x 7¾ in., 144 pp., 89 illustrations. The Bruce Publishing Co., Milwaukee, Wis. $1.

Treatise on Milling and Milling Machines. 6 x 9 in., 400 pp., 267 illustrations. Cincinnati Milling Machine Co., Cincinnati, O. $1.50.

MANAGEMENT AND COST ACCOUNTING

Cost Accounting and Burden Application. By Clinton H. Scovell. 5¼ x 7¾ in., 328 pp. D. Appleton & Co., New York. $2. (To be reviewed later.)

Ford Methods and The Ford Shops. By Horace L. Arnold and Fay L. Faurote. 7 x 10 in., 440 pp. The Engineering Magazine Co., New York. $5.

Industrial Leadership. By Henry L. Gantt. 6 x 9 in., 128 pp., 9 charts. Yale University Press, New Haven, Conn. $1.

Manufacturing Costs and Accounts. By A. Hamilton Church. 6 x 9 in., 452 pp., 139 illustrations. McGraw-Hill Book Co., Inc., New York. $5. (To be reviewed later.)

Principles and Practice of Cost Accounting. By Frederick H. Baugh. 6 x 9 in., 194 pp. F. H. Baugh, Baltimore, Md. $2.

The Predetermination of True Costs and Relatively True Selling Prices. By Frederic A. Parkhurst. 6 x 9 in., 104 pp., illustrated. John Wiley & Sons, Inc., New York. $1.25.

Valuation, Depreciation and the Rate-Base. By Carl Ewald Grunsky. 5¾ x 9 in., 387 pp. John Wiley & Sons, Inc., New York. $4. (To be reviewed later.)

MARINE ENGINEERING

Land and Marine Diesel Engines. By G. Supino. 6 x 9 in., 309 pp., 399 illustrations. J. B. Lippincott Co., Philadelphia, Pa. $3.75.

The Design of Marine Engines and Auxiliaries. By Edward M. Bragg. 6¼ x 9¼ in., 183 pp., 110 illustrations. D. Van Nostrand Co., New York. $3. (To be reviewed later.)

The Marine Steam Engine. By R. Sennett and H. J. Oram. 6 x 9 in., 502 pp., 414 illustrations. Longmans, Green & Co., New York. $6. (To be reviewed later.)

The Marine Steam Turbine. By J. W. M. Sothern. Fourth edition, 6 x 9 in., 561 pp., 330 illustrations. D. Van Nostrand Co., New York. $6.

MATERIALS OF ENGINEERING

Engineering Chemistry. By Thomas B. Stillman. Fifth edition, 5⅜ x 8¾ in., 760 pp., 150 illustrations. Chemical Publishing Co., Easton, Pa. $5. (To be reviewed later.)

Lubricating Engineer's Handbook. By John Rome Battle. 6 x 9 in., 333 pp., 114 illustrations and 16 pp. of ruled log sheets. J. B. Lippincott Co., Philadelphia, Pa. $4. (To be reviewed later.)

Mechanical Technology. By C. F. Charnock. 8½ x 5½ in., 620 pp., 503 illustrations. D. Van Nostrand Co., New York. $3.

Pipe and The Public Welfare. By R. C. McWane. 4¾ x 7¾ in., 165 pp., illustrated. The Stirling Press, New York. $1.

Steel and Its Heat-Treatment. By Denison K. Bullens. 5½ x 9 in., 431 pp., 223 illustrations. John Wiley & Sons, Inc., New York. $3.75.

The Chemistry and Technology of Paints. By Maximilian Toch. 6 x 9 in., 336 pp., 83 photomicrographic plates and other illustrations. D. Van Nostrand Co., New York. $4.

The Metallurgy of Steel. By J. W. Harbord. Fifth edition, 6 x 9 in., 933 pp. (2 vol.), 695 illustrations. J. B. Lippincott Co., Philadelphia, Pa. $12.50.

The Physico-Chemical Properties of Steel. By C. A. Edwards. 6 x 9 in., 229 pp., 181 illustrations. J. B. Lippincott Co., Philadelphia. $3.50.

MATHEMATICS

Elementary Course in Lagrange's Equations. By N. W. Akimoff. 6 x 9 in., 195 pp., 58 illustrations. Philadelphia Book Co., Philadelphia, Pa. $2. (To be reviewed later.)

Engineering Applications of Higher Mathematics. By V. Karapetoff. In 5 volumes, containing problems respectively on (1) Machine Design, (2) Hydraulics, (3) Thermodynamics, (4) Mechanics of Materials, (5) Electrical Engineering. 6 x 9 in., 60 to 115 pp. each. John Wiley & Sons, Inc., New York. $0.75 per vol.

Handbook of Engineering Mathematics. By Walter E. Wynne and William Spraragen. 4 x 6¾ in., 220 pp., 113 illustrations. D. Van Nostrand Co., New York. $2.

Seventy-two pages of this pocket-size work are devoted to the formulæ and methods of algebra, geometry, trigonometry, analytic geometry, calculus, hyperbolic functions and differential equations; 60 pages to the fundamental formulæ of theoretical mechanics, mechanics of materials and hydraulics; 24 pages to electrical formulæ and data, 10 to measurement, 17 to physical and chemical constants, and 29 to mathematical tables. It is intended primarily for students in engineering schools, and the authors have endeavored to make it a handy means of reference to the theoretical and applied mathematics used in engineering.

MECHANICS

Elementary Mechanics for Engineers. By Clifford Newton Mills. 4⅛ x 7 in., 127 pp., 36 illustrations. D. Van Nostrand Co., New York. $1.

The course given in this book is designed to form the basis for a semester's work of three hours per week, and presupposes a mathematical preparation on the part of the student that includes trigonometry. Principles throughout are briefly stated, it being intended that a thorough comprehension of their meaning and application shall be gained by the solution of problems, of which there are more than three hundred, many of them original.

Hydraulic Flow Reviewed. By A. A. Barnes. 9¾ x 6½ in., 158 pp., 11 plates. Spon & Chamberlain, New York. $4.50.

MUNITIONS

Manufacture of Artillery Ammunition. By L. P. Alford (editor in-chief), F. H. Colvin, R. Mawson, E. A. Suverkrop and J. H. Van Deventer. 6 x 9 in., 759 pp., 648 illustrations. McGraw-Hill Book Co., New York. $6. (To be reviewed later.)

POWER GENERATION

Coal, Its Economical and Smokeless Combustion. By J. S. Cosgrove. 8 x 5½ in., 273 pp., illustrated. Technical Book Publishing Co., Philadelphia, Pa. $3.

Engineering of Power Plants. By Robert H. Fernald and George A. Orrok. 6 x 9 in., 581 pp., illustrated. McGraw-Hill Book Co., New York. $4. (Reviewed in this issue.)

Gas Engine Ignitions. By E. B. Norris, R. K. Winning and W. C. Weaver. 6 x 9 in., 174 pp., 209 illustrations. McGraw-Hill Book Co., New York. $1.50.

Hydro-Electric Power. By Lamar Lyndon. 6 x 9 in. Vol. I (Hydraulic Development and Equipment), 499 pp., 235 illustrations. $5. Vol. II (Electrical Equipment and Transmission), 360 pp., 154 illustrations. McGraw-Hill Book Co., New York. $3.50.

Riveted Boiler Joints. By S. F. Jeter. 11 x 8 in., 155 pp., 52 illustrations. McGraw-Hill Book Co., Inc., New York. (To be reviewed later.)

Steam Boilers, Their Theory and Design. By H. de B. Parsons. 5¾ x 9 in., 377 pp., 158 illustrations. Longmans, Green & Co., New York. $4. (To be reviewed later.)

Steam Power. By C. F. Hirshfeld and T. C. Ulbricht. 5¼ x 8 in., 428 pp., 232 illustrations. John Wiley & Sons, Inc., New York. $2.

The Callendar Steam Tables. By H. L. Callendar. 5½ x 8½ in., 39 pp. Longmans, Green & Co., New York. $0.80.

PUMPS

Centrifugal Pumps and Suction Dredgers. By E. W. Sargeant. 6 x 9 in., 188 pp., 160 illustrations. J. B. Lippincott Co., Philadelphia, Pa. $3.25.

REFERENCE BOOKS

Elliott's Weights of Steel. Flexible leather, 6 x 9 in., 662 pp. The Penton Publishing Co., Cleveland, O. $20.

Handbook for Machine Designers, Shop Men and Draftsmen. By F. A. Halsey. 8½ x 11 in., 561 pp., 750 illustrations. McGraw-Hill Book Co., New York. $5. (Reviewed in this issue.)

The "Mechanical World" Pocket Diary and Year Book for 1917. 3¾ x 5¾ in., 264 pp. text, and 52 pp. diary. The Norman, Remington Co., American Agents. $0.35.

This handy and inexpensive English compilation of mechanical-engineering information, now in its thirtieth year of publication, has, it is stated, been subjected to a thorough revision. The section dealing with steam and steam engines has been largely rewritten, and a new section on the heat treatment of steel has been added, as well as tables giving dimensions of piston rings and governors, and for the calculation of helical springs.

Mechanical Engineers' Handbook. By Lionel S. Marks. 4½ x 7 in., 1,800 pp., 1,000 illustrations, flexible leather. McGraw-Hill Book Co., New York. $5. (To be reviewed later.)

Mechanical Engineers' Pocket Book. By William Kent. 4 x 6¾ in., 1,526 pp. John Wiley & Sons, Inc., New York. $5.

REFRIGERATION

Elements of Refrigeration. By Arthur M. Greene, Jr. 6 x 9 in., 478 pp., illustrated. John Wiley & Sons, Inc., New York. $4. (To be reviewed later.)

MISCELLANEOUS

Selling Your Services. 5½ x 8 in., 176 pp. The Sales Service Co., New York. $1.

It is the belief of the authors, whose names are not disclosed, that a man's services are to be marketed to the best advantage by employing the same selling principles that have proved successful in the disposition of other commodities, and with this in mind they have outlined the systematic methods of campaigning which they themselves followed in securing positions of responsibility. The volume includes numerous valuable suggestions regarding the advisability of changing employers and of hiring out to a competitor, hunting out opportunities for employment, the writing of cogent letters of application and situation-wanted advertisements, and procedure at an interview with a prospective employer. Examples of effective letters of application for positions as engineers, salesmen, foremen, correspondents, and accountants are given, which are easily susceptible of modification to suit particular requirements.

Handbook for Machine Designers

Handbook for Machine Designers, Shop Men and Draftsmen. By Frederick A. Halsey, B.M.E., Editor Emeritus of the American Machinist (Author of Slide Valve Gears, The Use of the Slide Rule, Worm and Spiral Gearing, The Metric Fallacy, etc.). McGraw-Hill Book Co., Inc., New York, 1916. Second Edition, revised and enlarged. Cloth, 8½ x 11 in., 561 pp., over 800 illustrations, including many full-page charts. $5.

This book places before the reader a large amount of information which heretofore had been spread over a great number of books, pamphlets, articles, papers, etc., and which for this reason was not available to those for whom this book was mainly written. It makes this information available to the practical man, whereas heretofore it has been available only to the student.

The book is quite broad in its scope and deals with all kinds of machine elements, as well as the strength of materials, mechanics, properties of the chief materials of construction, the study of heat, the steam engine, steam boilers, compressed air, etc., apparently with the aim of bringing together enough information in one volume to enable the designer to study, improve, and, in many cases, to even design a machine. In this the writer has succeeded admirably. Though more than one method or more than one set of formulæ are often given, yet the author has succeeded in avoiding all confusion.

The book should be of considerable use to any engineer who has to deal with machinery, and should be of especial use to the draftsman and designer and also to the shop man who wants to be more than a machine operator. The information is given in such a shape that, as a rule, very little mathematical knowledge is required to thoroughly understand the subject, though the author did not make an attempt to cut out all reference to mathematics or the use of mathematical formulæ. In many places graphical charts have been given, and many of these charts have been carefully analyzed.

The book is not exactly analytical, yet it gives enough analysis to lift it above a mere compilation and seems to aim to give not merely information but also understanding. Many concrete examples have been given, as well as many comparisons of existing mechanisms.

The material in the book is not original, nor does the author claim originality. An exception should be made as to those items which the author quotes from papers and books written at a previous period by himself, such as worm gears, helical gears, etc.

The book might be compared in its general get-up and its scope to the well-known Reuleaux's Konstrukteur, covering somewhat the same ground and with the same thoroughness. Reuleaux's Konstrukteur has been out of date for many years, and no amount of effort would ever bring it again to the same position it once held. Halsey's Handbook will fill for the English-speaking engineers the place which was once occupied by the Reuleaux work.

There are certain chapters which could have been shortened without doing much harm to the book as a whole, among which is the chapter on Cone Pulleys and Back Gears. There are also many tables in the various chapters which, though doubtless of some value, make the book too bulky, and more would have been gained if either some of them had been omitted and thereby the book had been made handier, or else if all or most of the tabulations had been placed in a separate volume. There is considerable duplication in some of the mathematical tables, and it would be of advantage to have these tables thoroughly reviewed before the next reissue of the book.

These minor objections notwithstanding, Halsey's Handbook is an important addition to the engineer's library.

A. L. DE LEEUW.

Automatic Screw Machines

Automatic Screw Machines. By Douglas T. Hamilton, Associate Editor of *Machinery* (Author of Automatic Screw Machine Practice, Shrapnel Shell Manufacture, Machine Forging, Bolt, Nut and Rivet Forging, etc.) and Franklin D. Jones, Associate Editor of *Machinery* (Author of Turning and Boring, Planing and Milling, Gaging Tools and Methods, etc.). The Industrial Press, New York, 1916. Cloth, 6 x 9 in., 342 pp., 150 illustrations. $2.50.

The automatic screw machine as a factor in modern mechanical production has become so important and is so widely used that it seems fitting that there should be a treatise specifically directed to it and its use.

The technical press has in the past given much attention to automatic screw machines, their methods of operation, and the character of work which can be economically done on such machines. While every day brings up new problems relating to their use, both the machines themselves and the work done on them have now been sufficiently standardized so that the public can be given some definite information regarding them which can be expected to be of more than transient value.

Such information has been brought together and with new material has been put in form for use by the authors of this book in a way to be of value both to the purchaser and owner of the machines and also to the operator, as well as to the designers of machines and of the tools and auxiliary

equipment required in their use. This work seems well adapted as a help to men who are employed to operate any of the types of machines described; from it they can obtain a better idea of the possibilities of the machine and its method of operation, thus enabling them to secure the best results in their work. It will also inform them as to the working of other makes of machines which at some time they may be called on to operate.

The authors have apparently given a comprehensive treatment of the subject, starting first with a detailed description of the mechanism of a number of well-known types of machines, and emphasizing the particular advantages of each and the classes of work for which they are adapted. Thus the particular relative advantages of single- and multiple-spindle machines are discussed, the authors pointing out on what type of work the multiple-spindle machines may give better results by insuring a higher rate of production, and stating reasons why, other things being equal, the single-spindle machine can produce work of a higher degree of accuracy.

Then, following this general description, the authors go into details as to the various tools used in the machines, including instructions as to the correct clearance angles of the tools and as to their hardening; also as to the speeds and feeds required. A chapter also deals with the attachments found useful in extending the scope of the work which can be handled in automatic screw machines, and another gives a detailed description as to methods of laying out cams.

Specific cases are worked out for a variety of kinds of work and for work of different materials in such a detailed way as to be a guide for setting up for other work of similar character, and specific instructions are given as to the procedure of setting up and operating each of the types of machines described.

Finally, a number of special and unusual jobs are described, showing a great range of work which comprises much of a character not usually thought of as being screw-machine work. This, through the ingenuity of specialists, has been made a part of the product of the automatic screw machine, the use of which, for many of these jobs, now outclasses all other methods of production.

LUTHER D. BURLINGAME.

Engineering of Power Plants

Engineering of Power Plants. By Robert H. Fernald, M.E., A.M., Ph.D., Whitney Professor of Dynamical Engineering, University of Pennsylvania, and George A. Orrok, M.E., formerly Mechanical Engineer, New York Edison Company. McGraw-Hill Book Co., Inc., New York, 1916. Cloth, 6 x 9 in., 569 pp., 309 illustrations. $4.

"This is not a treatise on power plants. It is simply an epitome of the subject arranged by the authors for convenient classroom use."

These are the first sentences in the preface of this book and may be taken as representing the authors' final opinion of their production, for it is probable that the preface of a book is the last word of the authors.

The statement is clearly a true one. It is not a treatise, because it does not discuss the principles of design either of power-plant units or of power plants themselves. It is an epitome, because it points out just what one finds in power plants of large and small capacity, tells something of how the various units operate, tells much about their comparative economy, and more about the cost of installation and operation.

The authors have certainly accomplished their purpose in writing this book, and it appears at an opportune time.

The development of power engineering during the last decade has been as wonderful as it has been important. New prime movers have been born and have grown to large proportions. The teacher and student, the designing and operating engineer, have realized what a valuable fund of information has been published in the technical press concerning these developments. It has remained for the authors of this book to present the reader with the essentials of the best in power-engineering practice at the present time, not only in this country but abroad.

The authors do not use many words to present their facts; on the contrary, they use short and concise sentences, and the reviewer is impressed with the very large amount of information which the book contains. There are two things which appear peculiar: (a) The order in which the chapters are arranged; (b) the comparatively small space devoted to the electrical generator. The book is very largely descriptive. It contains only simple mathematical formulæ clearly explained and easily understood. It discusses no theories but contents itself with the presentation of facts. It presents the results obtained in the operation of many distinct appliances and many complete plants. It does not place in economic comparison types of equipment which should not be compared.

The book will undoubtedly be used as a textbook as one of the authors has used it—"for *all* senior engineering students"—and all engineering students must know something about the engineering of power plants. With this book as a text the teacher with experience will be able to develop an admirable course of instruction on power engineering in its broadest sense. A goodly number of problems are distributed throughout the book. The problems have a true power-plant flavor and one feels sure the authors have had to solve many of them in practice rather than manufacture them for a textbook.

This book should meet with much favor entirely outside the classroom. The designers, the builders, the operators of power plants will all find much information of value to them in it. The designer will profit by a study of the relative economic-performance curves of various units which he wishes to install, the builder will find the tables of cost extensive, the operator will be able to learn what others have done to reduce operating costs and to observe from the curves what conditions of operation tend toward best performance with a given combination of appliances under varied conditions.

The title Engineering of Power Plants seems to fit the book, for while perhaps two-thirds of its contents relate to burning fuel for making steam and then the use of steam for making power, electricity or heat, the other third takes up internal-combustion engines and gas producers, compressed air, and hydraulic power. A few pages are devoted to the power plant of the steam locomotive.

This is an excellent book: good material well presented; the faults and errors are few.

The names of the authors on the back of the book are a sufficient guarantee of its contents.

It is well when engineers and engineering teachers coöperate. Books will be better as they learn to do so.

It is doubtful if there could be found two engineers whose knowledge of the problems of the engineering of power plants and the teaching of the subject to engineering students, better fitted them for the coöperation which resulted in this work.

L. P. BRECKENRIDGE.

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